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OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

DEVOTED TO

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JULY, 1861.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Bridge over the Theiss, and Tubular Foundations. By M. CEZANNE, Engineer des Ponts et Chaussées. Translated by J. BENNETT.

THE system of founding tubular piers by pneumatic fixtures is a happy imitation of a design conceived in 1841 by M. Triger for sinking a mine shaft in an island of the Loire, near Angers. It is but a few years since that it was adopted in England, and it has already met with many applications. Still, there are but few documents published upon the subject; and it is for this reason that I have undertaken to give an account of my own personal observations upon this matter.

The notice is divided into three parts:

The first contains a summary description of the bridge upon the Theiss, at Szegedin (Hungary), preceded by some indications of local circumstances. The second is devoted to iron arches. The third to tubular piers, and their pneumatic fixtures.

PART FIRST.

General Indications.—The South-east Austrian Railroad follows nearly the left bank of the Danube from Presbourg to Pesth. From this point, while the Danube bends to the south, the railroad is directed

to the south-east, and terminates at a quay upon the Danube, which it meets again at Basias.

This trace necessarily encounters all the affluents of the left bank, between Presbourg and Basias. The crossing of the Theiss is effected at Szegedin, 2·17 miles below its confluence with the Maros, upon a bridge, which is the object of this notice. By an agreement, dated June 10th, 1856, between the Austrian company and the imperial government, was determined,

1st, The trace of the centre line of the bridge.

2d, The distance between the abutments at 186 klofter, or 1157 feet.

3d, The height of the rails above the highest water of 1855, to be 26 feet.

It obliged the company to construct a durable bridge, and to finish all the work by July 1st, 1859, and remitted them one-half the duty upon wrought and cast iron.

These conditions allowed a great latitude to the company; and the study of the local circumstances controlled their decision.

The Theiss rises in the Karpathian Mountains, near the frontiers of Moldavia, of Bulkowine, and Transylvania. After coursing a circuit of 752 miles in a valley which is only 338 miles long, it enters the Danube, not far from Belgrade. Its gentle slope as compared with other rivers is seen in the following table, taken from a pamphlet by M. Michel, upon the navigation of the Danube.

Table of Slopes of some Rivers.

Name of River.	Slope per 1000 feet.	Difference between high and low water.
	Feet.	Feet.
Danube,	0·125 from Parsau to the sea.	
	0·400 above Vienna.	39·36
	0·043 in Hungary.	29·52
	0·0534 from Rassowa to the sea.	19·68
Theiss,	0·028 from Tibisca-Uhlak, near its source, to the Danube.	
	0·0081 near the Danube.	14·76
Rhone,	1·456 at its outlet from Lernau.	
	0·543 near Lyons.	
	0·742 at Valence.	
	0·288 at Tarascon.	
	0·053 at Aries.	
Rhine,	0·554	23·2 at inlet of canal from Rhone to Rhine.
Garonne,	0·440	30·7 at Ageu.
		42·6 at Langons.
Loire,	0·390	30·3 at Nevers.
Allier,		20·8 at Moulins.
Seine,	0·100	25·5 at Paris.
Nile,	0·144	42·7 at Upper Egypt.
Mississippi,	0·058	21·6 at Cairo.
Ohio,		65·5 at Cincinnati.

The velocity of the Theiss is generally from 0·98 feet to 1·96 feet at the surface; it attains, however, at Szegedin, 3·28 feet and 3·93 feet in high water.

The regime of the river is very regular. In spring the water rises slowly; it maintains nearly a constant level throughout the summer, and falls at the approach of winter. The minimum is always attained in the cold weather between October and March.

The highest water known, which was taken for a reference plane, occurred in April, 1855; the lowest water was observed in the winter of 1857–8, during the construction of the bridge; the difference was 26½ feet.

Hungary forms, between the Karpathes and the Danube, an immense triangular plain, which the Theiss traverses from the summit to the base, and which, in respect to public works, not many years since, was in a state of nature. The waters of the Theiss and of the Maros, at certain points, extended freely more than 43 miles from their beds, forming upwards of 247,114 acres of sorrily celebrated marsh.

One of the first essays for public improvement in Hungary was the formation, in 1846, of a vast syndicate of all the proprietors dwelling upon the Theiss and the Maros. A systematic regulation and endikement of the two rivers was undertaken. This work, interrupted for many years by the revolution, is now continued by the imperial government;* still, their effects are hardly appreciable, and it was admitted during the preparation of the project of the bridge, that there would be high water throughout the duration of the construction.

When the water stood at 20·4 feet, the width of the river on the site of the projected bridge was 738 feet.

The section of the profile was 1947 square yards. The delivery (calculated by the application of Eytelwein's formula to a great number of observations made with Woltmann's mill) was 1406 cub. yds.

And, consequently, the mean velocity was 0·72 yds. or 2·16 ft.

There is no stone or lime in the neighborhood of Szegedin; within 30 and possibly 60 miles range, cannot be found a pebble the size of a walnut. The sand itself must have been brought from afar, the river usually depositing a muddy slime, or occasionally a very fine sand, ill suited for masonry. Wood only is abundant, though the plain is barren as far as the limits of the horizon. The river brings it from Transylvania; it is usually composed of the trunks of pine, of a soft and coarse fibre, but of considerable length and diameter.

Szegedin was, in 1856, the head of the South-east Railroad, and so communicated easily with Pesth, where the Danube brought stone;

*The system adopted for this work consisted in substituting straight lines for the circuits of the river, and providing each bank with strong levees, 1312 feet apart. It was hoped by these means to increase the slope of the river, and to preserve the plain.

The diversion of the river was effected by digging a narrow canal during the low water, when they commenced enlarging and establishing its bed. Some of these diversions succeeded, they being navigable, while the ancient bed is under cultivation; but many of them have been filled up each year by the freshets. and can only be maintained by costly dredging; and the river has been entirely choked more than twenty times without subduing the perseverance of the dredgers. The sluggish and muddy waters of the Theiss and the Maros have a prodigious depositing power. We have seen at Szegedin, a single freshet deposit in a few weeks a bed of clay several yards in depth, and completely efface an enormous trench, excavated most zealously by the population of the city, who sought in it a remedy against the inundations which they anticipated from the construction of the bridge.

with Bohemia, where hydraulic lime was prepared; and finally, with France and England.

The low water being unusual, the Theiss is navigated at all seasons, except the icy, by steamboats from the Danube, and by large barges from 50 to 80 tons.

As for the bottom of the river, the soundings made in 1855 by the company showed, at the site of the projected bridge, an indefinite depth of very fine sand mixed with clay. It is easily undermined, but offers a certain resistance to compression.

General description of the Theiss Bridge.—The bridge at Szegedin (Pl. I., Fig. 1) is composed of eight rolled iron trussed arches of 136 feet span, supported by seven cast iron tubular piers, and two abutments in masonry, with one of which is connected a viaduct in masonry, with seven arches. The whole length of the structure is 1440·7 feet.

Arches.—The arches are parabolic in form; their sagitta is 16·84 feet.

Their springing is at 4·6 feet above the highest water on record.

The height for free navigation under the arches is, consequently, 21·4 feet.

Each arch is composed of four rolled iron trusses, each bearing a line of rails, and connected with each other by different systems of strutting. The two trusses belonging to each track are spaced at 5·7 feet.

The axes of the tracks are 13·12 ft. apart. The platform is formed of oak cross-beams, in section 9 ins. × 12 ins., and 28·5 feet long, spaced at 3·36 feet, and bolted upon the rolled iron trusses. These cross-sleepers bear directly the four lines of rails, the joist flooring, and the hand railing which bears the electric telegraph.

The length of cross-pieces is produced to 30·58 feet, projecting beyond the piers, thus allowing a space of 2 feet for the safety of the guards. There is no ballast upon the platform.

Piers.—Each pier (Pl. I., Fig. 2) is formed of two cast iron columns, 9·84 feet in diameter, bearing each a track, and consequently spaced 13·12 feet from axis to axis. These columns, whose sides are 1·37 ins. thick, are filled with piles and beton, and are connected by wrought iron stays. Their feet are enveloped with an enclosure of piles and sheet-piling, provided with beton, and protected by an enrockment.

The column properly so called, is surmounted by a cast iron capital, and by a square body of wrought iron, upon which are bolted the cast iron shoes which receive the ends of the trusses. The two square bodies of the same pier are strongly connected together by a system of diagonal braces.

The junction of the square bodies and the capitals is concealed by a wrought iron cornice.

The columns descend about 39 ft. below the summer level, or, say, 29·5 ft. into the bottom of the river. The point of the interior piles

penetrates 19·6 feet lower. Each pier is secured above by an ice breaker of oak.

The heads of the two neighboring piers are connected, and held at an invariable distance by the stringers of the trusses which they bear.

Abutments.—Upon the right bank, where lies the city of Szegedin, the earth is at the level of high water; the bank of the river is occupied below the bridge with merchandise platforms, and above by the city harbor. To maintain a communication between the harbor and these platforms, the abutment upon this bank has been prolonged by a viaduct. The first six arches are full centered, with a span of 18·53 feet. The last is surbased, and skewed 83°. It has in the axis of the bridge an opening of 31 feet. It is constructed in the helicoidal system.

The piers of the viaduct are of cut stone; the arches, spandrils, and return walls are faced with red and white brick.

The abutment proper is faced at the heads with cut stone, and with rustic-work at the four corners. In the interior of the mass, there are two modes of cut stone construction: one is in the form of an arch, and receives the springing of the iron arches; the other is composed of four walls stepped, starting from the rear summit of the abutment, and descending towards the springing of the arches (Pl. I., Fig. 1, dotted lines). These walls each receive a wrought iron mooring of the truss (2d part). The remainder of the abutment is built of rubble masonry. At the demand of the military engineers, two horizontal cast iron cylinders were imbedded perpendicularly to the axis of the bridge, serving the purpose of mining chambers.

Upon the left bank, there is no viaduct, and the abutment is connected with the embankment by return walls.

The two abutments are founded, in the same manner, upon a mass of beton, contained in an enclosure, and poured dry upon the piling designed to consolidate the bottom of the excavation.

There are 80 piles under the right abutment, and 120 for the total foundation of the left abutment; the heaviest loaded bear 88,000 lbs. Some were driven to an absolute refusal; the mean set was at $\frac{4}{10}$ths inch for 10 blows of a ram weighing 2200 lbs. with a fall of 19·6 ft. The beton is loaded at a maximum of 37·4 lbs. per square inch. The calcareous sandstone which receives the heels of the arches bore during the proof trial, 199·4 lbs. per square inch.

PART SECOND.

Iron Arches.—The iron arches of the Theiss bridge are copies of the arch bridges constructed upon the Northern Railroad under the direction of M. Maniel, Engineer-in-Chief "des Ponts et Chaussées." They are composed (Pl. I., Fig. 1,) of rolled iron trusses, in which we may distinguish three parts:—

1st, The arch proper, which is parabolic, and with a rise of $\frac{1}{8}$ of the span.

2d, A horizontal top stringer, tangent to the summit of the arch.

3d, The spandrils formed of vertical equidistant uprights, and inclined struts, describing with the uprights a series of triangles decreasing towards the summit.

The section of these different pieces is a double **T**, formed of a web and of two stiffening plates fastened with angle-irons.

The pieces of the spandrils are connected with the arch and the top stringer in the same way; the webs of these pieces are prolonged until they meet with the web of the arch or that of the stringer, against which their section rests. The stiffening plates of the stringer or those of the arch return with their angle-irons, and envelop the stiffening plates of the spandrils, thus strengthening the section which without it would present a weak point where the angle-irons of the spandrils abut against those of the arch and stringer. The angles formed by the webs of the different pieces are filled exactly by wrought iron triangles, whose base is cut according with the curve of junction. Finally, the whole assemblage is enveloped with two covering plates, cut in the shape of a goose's foot, and presenting a scarf towards each piece.

The arch proper is traced so that the neutral axis of the different sections forms, from the first vertical upright to the last, a parabola, with a span of 134·78 feet, and a rise of 16·84 feet. The total opening of the arch from heel to heel is 135·85 feet.

The truss is divided into 20 equal sets by the uprights, which are 6·73 feet from axis to axis.

The five uprights of the summit are imaginary, being replaced by a wrought iron plate in full.

The stringer is not perfectly horizontal; it presents, besides the variations in thickness of the wrought irons, a camber of 1·37 inches, obtained at the moment of raising by an energetic wedging of the arches.

The two arches on the same side of the axis of the bridge bear one track; they are, from centre to centre, 5·7 feet.

The two middle arches are, therefore, 7·42 ft. from centre to centre.

The width of the intermediate space between the axis of the rails is 8·2 feet.

The four arches are made solid by three systems of connexion, viz:

1. A horizontal strutting in the plane of the neutral axes of the top stringers (Pl. I., Fig. 2).

2. A strutting whose surface envelops the neutral lines of the arches.

The drawings show the arrangement of these struttings, each member of which is formed of two **T** irons, riveted face to face, and at their ends embracing binding gussets, which are fastened to the trusses by two angle-irons.

3. A system of vertical stays or ribs distributed in three vertical planes on each side of the axis of a bay, to wit:

1. In the vertical plane of the second vertical strut two stages of diagonals.

2. In the vertical plane of the fifth vertical strut one stage of diagonals.

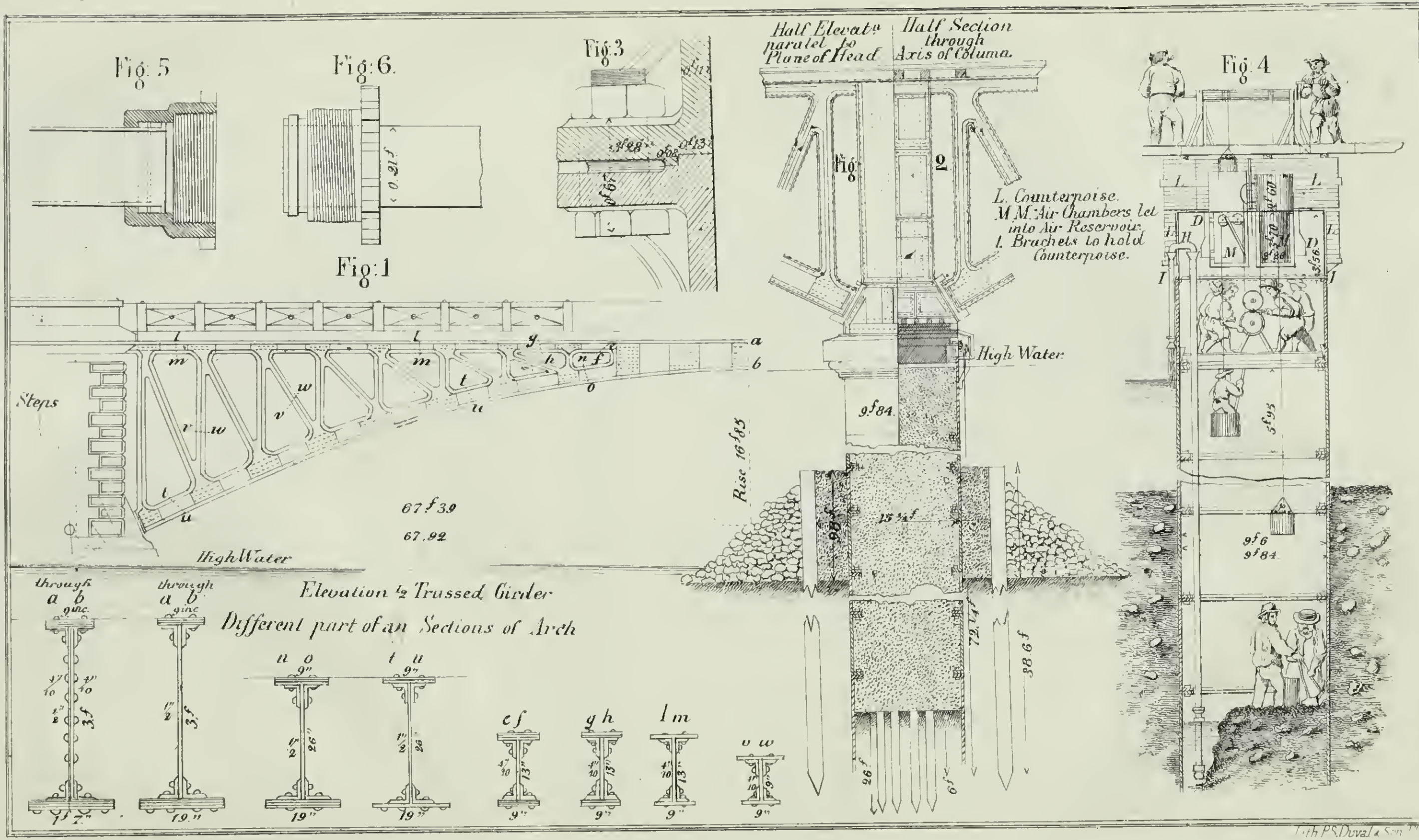


Fig: 5
Fig: 6.
Fig: 3
Fig: 1
Fig: 4
Half Elevatn parallel to Plane of Head
Half Section through Axis of Column
Fig 2
L. Counterpoise.
M.M. Air Chambers let into Air Reservoir.
I. Brackets to hold Counterpoise.
High Water
Steps
High Water
Rise 16f85
67f39
67.92
Elevation ½ Trussed Girder
Different part of an Sections of Arch
through a b
through a b
u o
t u
c f
g h
l m
v w
9f84
15¼f
72.14f
38.6f
26f
6f
5f95
9f6
9f84

3. In the vertical plane of the eighth vertical strut one tier of diagonals.

These diagonals are formed of two **T** irons, opposed face to face, riveted at their ends upon binding gussets fixed upon the arches, and in their middle upon a plate of the same thickness as the gussets.

At the ends of the arches, a wrought iron plate perpendicular to the direction of the last element, is riveted upon two angle irons which are fastened to the web of the arch. This wrought iron plate bears upon the shoes through the intervention of iron wedges.

Against the abutments are interposed between the heel of the arch and its shoe, four couples of steel wedges, which are driven tight when a cold snap occasions any play between the heel and shoe (see Note A).

The top stringers enter into square bodies and abut against each other at the middle of the pier. They are not directly riveted together, but are connected by means of horizontal plates embracing them (Plate I., Fig. 2).

Upon the abutments the top stringers are received by a horizontal cushion of cast iron imbedded in the plinth. The web of the stringer is strengthened each side by two wrought iron plates ·43-inch thick; all these five plates are pierced with a hole, in which is inserted a steel dowel 1·98 inches in diameter, and projecting beyond each face of the stringer.

Two iron ties, 1·96 ins. diameter, wormed at one end and flattened at the other in form of a ring, lay hold of this dowel by their rings, and, penetrating the brick masonry which forms the platform of the abutment, traverse the upper stones of the stepped walls (Plate I., Fig. 1) and the cast iron pillows imbedded in these stones.

The wormed ends of these ties receive screws, whose tightening draws the truss towards the abutment.

The ends of the steel dowel are wormed and provided with nuts which hold fast the rings of the tie-rods.

All the parts of the trusses receive two coats of red lead paint, and two coats zinc grey.

A measurement of the bridge gives the following results:

Designation of parts.	Partial weights.	Number of parts.	Totals.
	lbs.		lbs.
An arch without its struttings,	59890·6	4	239,562
Strutting between two arches of the same track, . .	19617·4	2	39,235
Strutting of intermediate space,	20332·0	1	20,332
An entire truss, . . .			299,129

Weight per running foot $\frac{299129}{136}$ = 2,199 lbs.

If we compare with the total of the above table:

1st. The weight of the platform, of the tracks, and the hand rails, at	140,250 lbs.
2d. The weight of the proof load, about 2628 lbs. per running foot of track, ...	748,000 "
Total,	888,250 "

We see that the iron arch bears permanently ·47, and accidentally the triple of its own weight.

Theory of the Arches.—In the case of a uniform load, the equidistant uprights transmit equal weights to the arch; the curve of pressures or of equilibrium is a parabolic polygon, as in suspension bridges. If, then, the axis of the arch coincides with the parabolic polygon, there will not be, on the supposition of an incompressible arch, any tendency to derangement; the inclined struts will receive no thrust, and it will be easy to determine either by calculation or graphically the thrusts on each of the elements of the arch.

When the load is not uniformly distributed, the uprights transmit unequal pressures upon the arch, which, on the supposition of its being jointed, have a tendency to a change of form. If the uprights are connected by inclined struts forming a series of triangles incapable of a change of form, the arch will preserve its figure, but the inclined struts will produce reactions which must be taken into account in the study of the forces acting upon the different elements of the arch. This investigation may be made by a graphic process easily applied and which is suggested by the theory of the funicular polygon and that of jointed systems.*

This method being applied to the different hypotheses upon the position and magnitude of the loads will give, for the case considered, the value of the efforts in each of the elements of the arch. The section of each element will be determined by dividing the greatest of these efforts found for the element by the co-efficient of work adopted per foot of surface.

The co-efficient of work admitted for the Theiss bridge is, for the elements of the arch proper, which always resists compression, 5 kilogrammes per square millimetre, or 7122 lbs. per square inch.

For the uprights and inclines, which sometimes resist tension and sometimes compression, according with the position of the movable loads, 2 kilogrammes per square millimetre, or 2849 lbs. per square inch.

For the top stringer, whose parts act first as elements of the arch, then as beams fastened upon neighboring uprights and loaded on the middle with a part of the load, that of a locomotive axle for example, and finally as a tie between two piers (see the Third Part), the maximum co-efficient adopted was 7 kilogrammes per square millimetre, or 9971 lbs. per square inch.

The form of the elements and arrangement of the wrought iron pieces are not indicated by any theory, but by practical considera-

* The theory of this graphical process is thoroughly described in a memoir written for the Northern Railroad Company, advocating the projects of metallic bridges constructed upon the line from Saint-Quentin to Erquelines.

tions. It was also to facilitate the execution that a uniform section was adopted for all the inclines and vertical uprights, and that the section of the top stringer and that of the arch were not changed continuously. The top stringer presents only four different sections; the arch presents five, which increase from the springing towards the summit, contrary to the usual custom in metallic arches and in bridges of masonry.

The results of the resolution of the above mentioned efforts justify this anomaly. The weight of the structure being inconsiderable in comparison with that of the movable loads, the curve of pressures departs widely from the axis of the arch. Hence arises a tendency towards a change of form, which is resisted by the energetic action of the inclines; these actions modify the distribution of efforts in the arch and may increase those at the summit and diminish those at the springing line.

When the spandrils of the arch are not constructed so as to support without inconvenience the variations in efforts arising from the change of place of the movable load, it is requisite that the permanent weight should be such that the curve of pressures should not depart from the arch proper, or that it should remain within certain limits traced in this arch. This is a condition rigorously observed for arches in masonry or in cast iron.

Construction of Arches.—The wrought iron arches were forged in Wales, and worked at Paris by MM. Ernest, Gouin & Co. The riveting, as far as possible, was made by machinery.

The pieces of wrought iron were of such weights and dimensions that they could be stowed in the railroad wagons and so forwarded to Szegedin. Some wagons loaded at the work-shops of MM. Ernest, Gouin & Co., went through without change to Szegedin, having passed the Rhine upon the steam pontoon of *Rurhort.* The greatest part, however, of the pieces sent from Paris were shifted at Dresden.

The trusses of wrought iron were again united at Szegedin, with the elements sent from Paris, and put in position without centerings in the following manner:

A service bridge of carpentry was constructed above the site of the bridge at the level of high water, which is below the springing of the arch. On this service bridge could be brought all the materials for the piers near to the work, and the passenger and baggage trains which were stopped at Szegedin by the Theiss, were forwarded by it towards Wallachia. It had in its middle a movable part, formed of an iron trellis bridge with 59 ft. opening in the clear, weighing 55,000 lbs. and was raised in one piece by four cranes on the passage of a boat. The service bridge was connected with the scaffolding of the piers, and with a stockade 8·2 ft. wide raised in the middle of each arch.

The arches were constructed upon the right bank in a great enclosure above the bridge, in which were assembled all the tools and plans of the work; they were laid horizontal and parallel to the axis of the bridge. To bring an arch in position it was made to undergo a series

of motions alternately perpendicular and parallel to the axis of the bridge during which it maintained its first direction; it was then brought upon the service bridge and drawn in front of the archway for which it was designed. By a final motion perpendicular to the preceding, the arch was pushed between the two piers upon which it was to rest. All these movements were made by means of iron wagons with four axles perpendicular to each other in couples and moved by strong screws (Plate I, Figs. 12, 13, and 14). The wheels of one system of axles were 4·92 ft. apart; those of the other were 9·84 ft. The same wagon being placed upon the crossing of a track of 9·84 ft., with a track of 4·92 ft. perpendicular to the first, could be pushed at will upon either track. It only required the regulation of the height of the movable axles so as to bring in contact with the rails those wheels answering to the track on which it was wished to move.

The method of moving the above named arches is readily seen. The arch is laid upon three wagons; one at the summit, the others at the ends. In the movements perpendicular to the bridge the three wagons advance parallel, each upon a track 4·92 ft.; these three tracks were cut at right angles by the track of 9·84 ft.; on arriving at the crossing, which occurs simultaneously for the three wagons, by manœuvring their movable axles, the whole system is pushed upon the 9·84 ft. track, parallel to the service bridge. Thus we arrive upon the service bridge by three tracks of 4·92 ft., and pass along it by one track of 9·84 ft., having the same axis as the regular tracks, and leave it by three tracks of 4·92 ft. placed upon the scaffolding of the piers at the level of the service bridge and upon the above mentioned stockade.

All the arcs are thus brought in their place. The mean distance of transportation for the majority of the arches was 1968 ft. upon six different directions and so with five crossings.

Motion was effected by two capstans, each worked by eight men; a portion of the track had a slope of 0·03; the velocity was about 9·84 ft. per minute. A change of direction required an hour. There were two crossings upon the service bridge, the one for entering and the other for leaving it. The whole distance between them had to be described in the interval of the passage of two trains.

It was at first proposed to bear the arches endwise upon two wagons only. Many trials for that purpose were made in the work-yard. The operation was found to be feasible but delicate, and any accident might have been attended with serious consequences; the men might be killed and the arch might fall into the river. It was decided to convey the arches flatwise, which multiplied the operations but lessened the chances of accidents.

The increased manœuvring exacted by the flatwise conveyance was considerable. It became necessary to construct a third track of 4·92 ft., that of the middle, and to manage three wagons instead of two. Moreover, the arches had no stiffness in the horizontal plane, and before laying them upon the wagons they had to be strengthened with

wooden trusses. Finally, the raising the arch in the vertical plane was much more complicated upon the river than in the work-yard.

This operation was accomplished by means of seven crabs, distributed along the arch, they laying hold of the horizontal top stringer; while the springings sustained by the wagons moved towards the crabs to keep pace with the raising. Nothing was easier than to effect this in the work yard where the crabs found a natural support upon the ground; but in the river it was necessary to construct a flying bridge from one pier to the other to hold up the crabs. It would then be necessary to construct similar flying bridges for all the arches, or to transport them from one arch to the other. The last method was adopted. The raising of the arch was thus composed of the following operations:

1. The establishment of a fly bridge, sustained by eight enormous beams about 65·6 ft. in length, and resting at one side upon the scaffolding and at the other upon the stockade in the middle.
2. The raising the trusses to stiffen, in a horizontal direction, the arch laid in the work-yard upon the wooden wedges.
3. The bringing the wagons under the arch (the tracks having been constructed before) and freeing the latter from the wedges which had supported it.
4. The landing the arch in its place.
5. The erecting of the seven hoisting crabs along the top cord.
6. The raising the arch, in the vertical plane, setting it in position, and wedging it upon the cast iron cushions.
7. The taking down of the crabs, and returning to the work-yard the wagons and wooden trusses to commence anew the same series of operations.

When one bay was raised, all the fixtures (crabs, stagings, "tendeurs," &c.,) had to be landed, and the flying bridge had to be taken down and moved to the next bay.

Notwithstanding the complication of these operations, the thirty-two arches of the bridge were raised with only one equipment of wagons, of crabs, and of fly bridges, in four months, without any interruption of the navigation or the stopping a single train. The eight last arches were raised in fourteen days, from the 9th to the 23d Oct., 1858.

Below are some principal dates of the construction:

November, 1856.—Approbation by the Minister of the plan proposed by M. Maniel, Director General of the Austrian Society. Conclusion with MM. Ernest, Gouin & Co. of the agreement for furnishing and *setting up* of the cast and wrought iron pieces. Shortly after, the conclusion of the contract for carpentry and masonry.

March 1st, 1857.—Driving of the first piles of the scaffolding and of the service bridge.

July 7th, 1857.—The laying of the first cast iron column.

November 23d, 1857.—Inauguration of the service bridge for the passenger and merchandise trains.

Dec., 1857, Jan. and Feb.. 1858.—Winter; the thermometer varied from 14° to − 4° (Fah.) The works of the pneumatic foundations

and of masonry were suspended. The wrought iron was continued; piling was driven night and day in the cast iron columns.

March 23d and 24th, 1858.—A menacing ice-breaking for forty-eight hours, followed immediately by the opening of navigation and the renewal of the work.

June 15th, 1858.—Raising of the first arch.

Oct. 23d, 1858.—Raising of the thirty-second and last arch.

Nov. 23d, 1858.—The strutting and flooring of the bridge being finished, the trial proof was made.

Dec. 2d, 1858.—The inauguration.

Trial Proofs.—The bridge being uniformly loaded with (8000 kil. per metre) 5365 lbs. per running foot, and consequently the piers in equilibrium (see Third Part), the flexures were as a mean 0·47 ins. for the intermediate bays, and ·63 in. for the two end arches, whose top stringers were not moored upon the abutments (see Note A).

The passage of an ordinary train upon a track gives the following maxima deflections:

Upon the exterior arch of loaded track, . .	·31 inches.
Upon the interior arch, . .	·25 "
Upon the interior arch of unloaded track, . .	·14 "
Upon the exterior arch, . .	·08 "

Which proves that the four arches are, in a certain degree, solid.

(To be Continued.)

Description of a Pier erected at Southport, Lancashire. By Mr. H. Hooper, Assoc. Inst. C. E.

From the London Artizan, May, 1861.

This pier was constructed at right angles to the line of promenade facing the sea, on an extensive tract of sands reaching to low water, a distance of nearly one mile. Its length was 1200 yards, and the breadth of the footway was 15 feet. At the sea-end there was an oblong platform, 100 feet long, by 32 feet wide, at right angles to the line of footway. The superstructure was supported upon piers, each consisting of three cast iron columns, and each column was in three lengths. The lowest length, or pile proper, was sunk into the sand to the depth of 7 or 9 feet. These piles were provided at their bases with circular discs 18 inches diameter, to form a bearing surface. A gas tube was passed down the inside of each pile, and was forced 4 inches into the sand; when a connexion was made with the Water Company's mains, a pressure of water of about 50 lbs. to the inch was obtained, which was found sufficient to remove the sand from under the disc. There were cutters on the under side of the discs, so that, on an alternating motion being given to the pile, the sand was loosened. After the pressure of water had been removed about five minutes, the piles settled down to so firm a bearing that, when tested with a load of 12 tons each, no signs of settlement could be perceived. The upper lengths of the columns had cast iron bearing plates, for receiving the ends of the longitudinal lattice girders, each 50 feet long and 3 feet deep. The centre row of girders having double the duty of the outside

ones, top and bottom plates were added. The weight of wrought iron work in each bay was 4 tons 5 cwt., and of cast iron work 1 ton 17 cwt. The second bay from the shore was tested by a load of 35 tons, equally distributed, when the mean deflection of the three girders, in 24 hours, was $1\frac{1}{2}$ inches, and there was a permanent set of $\frac{1}{2}$ inch, on the load being removed.

The advantages claimed for this mode of construction were—1st, Economy in first cost, especially in sinking the piles, which did not amount to more than $4\frac{1}{2}d.$ per foot. 2d, The small surface exposed to the action of wind and waves. 3d, Similarity of parts, thus reducing the cost to a minimum. 4th, The expeditious manner of obtaining a solid foundation—an important matter in tidal work. 237 piles were thus sunk in six weeks.

The estimated cost of the pier and approaches was £10,400. The works had been completed for £9319, being at the rate of £7 15*s.* 4*d.* per lineal yard. The pier was designed by Mr. Brunlees, M. Inst. C. E., and the superintendence of the construction was entrusted to the author, as resident engineer, Messrs. Galloway being the contractors.

Proc. Inst. Civ. Eng., March 5, 1861.

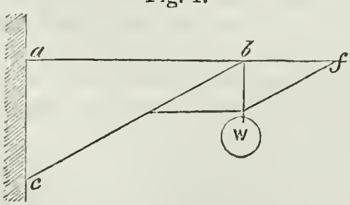
On Lattice Girders.

From the Lond. Artizan, May, 1861.

As girders constructed with a lattice web are now becoming numerous, it is very desirable that some ready means of calculating the strength or dimensions of any lattice combination should be generally known; we therefore purpose to enter fully into an investigation of the principles of such structures. Many theories of lattice girders have been published, all on the same principle, that we shall adopt in the present paper, and they are all tolerably simple, but with the one disadvantage of being expressed by trigonometrical qualities, and this we shall especially avoid, so that our calculations may be readily comprehended by those who have not studied the elements of trigonometry.

We will commence with some preliminary remarks upon the resolution of forces, confining ourselves to the problems which have reference to our present subject.

Fig. 1.



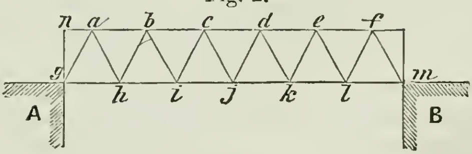
Let $b\,c$ (Fig. 1) represent a beam fixed into a wall obliquely, as shown, and let its upper end be prevented from deflecting by a flexible tie $a\,b$; from the point b let a weight w be suspended, then will this weight be

transmitted to the wall $a\,c$ through the bar $b\,c$, solely for the tie $a\,b$ being flexible, cannot bear any part of the load when in a horizontal position, although it will be subject to a certain amount of tension, produced by the tendency of $b\,c$ to revolve round the point c. We may now state axiom No. 1; deduced from the foregoing remarks it is as follows:—

If a triangular frame of bars be fixed at two of its angles, and a force be caused to act at the remaining angle, its direction lying in the plane of the triangle, then will two bars be strained by forces acting in the direction of their length, viz., the bars containing the angle on which the force acts. No bending moment can act upon the bar $b\,c$, because its extremity $b\,c$ cannot deflect.

It now remains for us to find the intensity of the strain on the elements $a\,b$, $b\,c$, which we may accomplish by the well-known principle of the parallelogram of forces. Complete the parallelogram $b\,e\,\text{W}\,f$, then, if $b\,\text{W}$ represents the weight or force acting at the angle b, $b\,e$ will be equal to the strain on $b\,c$, and $b\,f$ or $e\,\text{W}$ will represent the strain on $a\,b$; hence, the three forces are represented by the three sides of the triangle $b\,e\,\text{W}$, which is similar to $b\,f\,\text{W}$, and also to $a\,b\,c$, hence the strain on $b\,c = \text{W}\,\frac{b\,c}{a\,c}$ and that on $a\,b = \text{W}\,\frac{a\,b}{a\,c}$, hence we may say, generally, if W is equal to the load carried by one inclined bar, as in the present case, d being the depth of the frame and L the length of the inclined bar, then the strain on the inclined bar will be, $\text{S} = \text{W}\,\frac{\text{L}}{d}$; and if l be the length of the horizontal bar, the strain on the horizontal bar will be, $\text{S} = \text{W}\,\frac{l}{d}$. This case is an exact illustration of the condition of the bars in a lattice girder, to which we will now turn our attention.

Fig. 2.



Let $a\,f\,m\,g$ (Fig. 2) represent a lattice girder composed of one series of inclined bars, whose extremities are maintained in position by the top and bottom horizontal members or flanches. Let us call W the load acting on any bar, supposing them to be all of equal length, then L being the length of the lattice bars, the strain on that one will be $\text{S} = \text{W}\,\frac{\text{L}}{\text{D}}$ where D is the depth of the girder. All measurements are from centre to centre of the pins by which the joints are united.

Let $v = a\,b = b\,c = h\,i = i\,j = etc. =$ the distance between two consecutive joints, then, if n equal the number of these distances, or of the triangles, the span of the girder is represented by $n\,v$. We will

first turn our attention entirely to the strains on the diagonal bars, leaving the flanches for a subsequent part of our paper. Let a load, W, be caused to act upon the apex d, x triangles distant from the pier A, then will that part of the load which is borne by A be the load upon the bars between d and A, and the remainder of W will be the load upon the bars between d and B. We may easily, by the laws of the lever, find the proportion of W borne by each point of support; but we will first pause to lay down our second axiom, which is, that *the strain on any lattice bar is due to and proportional to the load passing to a point of support situated so that the bar is between it and the load.*

The part of the load borne by B will be $= \text{W}\,\frac{x\,v}{n\,v} = \text{W}\,\frac{x}{n}$, and therefore the strain on any lattice bar between d and B will be $= \text{W}\,\frac{\text{L}\,x}{n\,\text{D}}$. We may similarly find the strain on the other part of the girder between d and A. The next point to be considered is the nature of the strain on any bar, and this is a matter of observation; thus it is compressive on $d\,k$, $e\,l$, etc., but tensile on $e\,k$, $f\,l$, hence our third axiom. *If the direction of any strain is from the foot of the diagonal towards the summit of the same, it is a tensile strain, and vice versa.* If there be an uniform load equal to w per lineal foot distributed over the whole girder, it will have the same effect as a number of small concentrated loads placed immediately above the apices or joints, each of which is equal to $w\,v$, and the total load on any bar may be found by ascertaining what proportion of each load passes through such bar to the piers, summing the tension and compression loads, and subtracting one from the other. We shall indicate all tensile strains by the sign — (minus), and all compressive strains by the sign + (plus). Let the load be placed upon the top flanch of the girder, then for the first joint, $x = \frac{v}{2}$; for the second, $x = \frac{3\,v}{2}$, etc.; and the proportion of any load borne by one pier is $= w\,v\,\frac{x}{n}$, n being constant, and being the denominator in every quantity; let, therefore, $w' = \frac{w\,v}{n}$, then the proportion of any load on one pier, the load being at a distance x from the *other* pier, is $= w'\,x$. The following summations show the strains on various consecutive diagonals, commencing at one of the piers, for the form shown in Fig. 2:

First bar	$\frac{w'\,\text{L}}{2\,\text{D}}\left\{1 + 3 + 5 + 7 + 9 + 11 + \ldots + (2\,n - 1)\right\}$
Second bar	$\frac{w'\,\text{L}}{2\,\text{D}}\left\{- 1 - 3 - 5 - 7 - 9 - \ldots - (2\,n - 3) + 1\right\}$
Third bar	$\frac{w'\,\text{L}}{2\,\text{D}}\left\{1 + 3 + 5 + 7 + 9 + \ldots + (2\,n - 3) - 1\right\}$
Fourth bar	$\frac{w'\,\text{L}}{2\,\text{D}}\left\{- 1 - 3 - 5 - 7 - 9 - \ldots - (2\,n - 5) + 1 + 3\right\}$
Fifth bar	$\frac{w'\,\text{L}}{2\,\text{D}}\left\{1 + 3 + 5 + 7 + 9 + \ldots + (2\,n - 5) - 1 - 3\right\}$

And so forth for all the others. By inspecting these series we notice that the strain on each tie is equal to that borne by the following strut, supposing the ties and struts to be of equal length. If the girder be suspended by the top flanches, as is sometimes the case, we shall commence with a tie instead of a strut.

Let us now take a practical case, whereby to exhibit the application of the above method. Let a bridge be required to carry a single line of railway, consisting of two girders composed of 10 equilateral triangles, such as are known as Warren's Girders, each division or base of a triangle, and therefore each lattice bar being 8 ft. long. The depth will then be 6·928 ft., which we will call 7 ft. Taking the weight of the bridge at $\frac{1}{2}$ ton per foot run, and that of the load at 1 ton, we have a total load of $1\frac{1}{2}$ tons, or $\frac{3}{4}$ ton on each girder, we will ascertain the strain on the various bars under a full load, allowing 4 tons per sectional inch for compression and 5 tons for tension in determining the sectional areas of the bars. $w' = \frac{w\,v}{n} = \frac{\cdot 75 \times 8}{10} = \cdot 6$, and $\frac{\text{L}}{\text{D}} = \frac{8}{7} = 1\cdot 143$ nearly; therefore, $\frac{w'\ \text{L}}{2\ \text{D}} = \cdot 3429$, say, $= \cdot 343$. Then the strains and sectional areas will be:

Bar.		Strain.	Sectional Area.
1st.	$\cdot 343 \left\{ 1 + 3 + 5 + 7 + \text{etc.} + 19 \right\}$	= 34·3 tons.	8·575 sq. ins.
2d.	$\cdot 343 \left\{ 1 - 1 - 3 - 5 - \text{etc.} - 17 \right\}$	= 27·44 "	5·488 "
3d.	$\cdot 343 \left\{ 1 + 3 + 5 + \text{etc.} + 17 - 1 \right\}$	= 27·44 "	6·86 "

and so forth. It is evident that a total load would not produce the maximum strain on every bar, for there are both plus and minus signs in the series; hence to find the maximum strain we must make those terms which diminish the strain as small as possible, and those which increase it as large as possible. This is done by taking the former as produced by the weight of the structure only, the latter being calculated for the total load; w' will then have two values, one for the gross load $w' = \cdot 343$, and for the minimum load $w' = \cdot 114$. Then will the strains and sectional areas become:

Bar.		Strains.	Areas.
1st.	$\cdot 343 \left\{ 1 + 3 + 5 + 7 + \text{etc.} + 19 \right\}$	= 34·30 tons.	8·575 sq. in.
2d.	$\cdot 343 \left\{ -1 - 3 - 5 - \text{etc.} - 17 \right\} + \cdot 114 \times 1$	= 27·67 "	5·534 "
3d.	$\cdot 343 \left\{ 1 + 3 + 5 + \text{etc.} + 17 \right\} - \cdot 114 \times 1$	= 27·67 "	6·917 "
4th.	$\cdot 343 \left\{ -1 - 3 - \text{etc.} - 15 \right\} + \cdot 114 \left\{ 1 + 3 \right\}$	= 21·50 "	4·300 "
5th.	$\cdot 343 \left\{ 1 + 3 + \text{etc.} + 15 \right\} + \cdot 114 \left\{ -1 - 3 \right\}$	= 21·50 "	5·375 "

and so on. These are the minimum areas, and of their adoption we shall presently speak. We will now pass on to the top and bottom flanches,

first treating the strains upon them generally. We must again refer to Fig. 2. The strain on $g\,h$ will be that produced by the strains on $a\,g$, which is resolved vertically upon the pier and horizontally on the lower flanch; therefore, if the line $a\,g$ represents the strain on that bar, $a\,n$ equals the strain on $g\,h$; this strain passes on to h, where it is increased by the strain on $b\,h$, which is resolved between $h\,i$ and $a\,h$; hence the increment is represented by $a\,b$. When $b\,h$ is the strain on $b\,h$, this strain passes on again, being increased at every joint by a similar quantity until it meets, and is reacted upon by the strain acting in the opposite direction. The greatest strain on the flanches will exist when the bridge carries the total load. We will work out the strains on the flanches for the case we have selected first for the lower flanch. The strain on the first tension bar will be equal to the strain on the first diagonal $\times \frac{v}{2} \div$ length of diagonal; but the triangles being equilateral, $v =$ the length of diagonal; hence the strain on the first tension bar is half the strain on the first strut. The strain produced by that on any other strut is equal to the strain on such strut. The minimum strain and area of each tie-bar in the bottom flanch of one girder will be as follows:

Bar.		Strain.		Sectional Area.	
1st.	$\frac{34 \cdot 3}{2}$	$= 17 \cdot 15$	tons.	$3 \cdot 43$	sq. in.
2d.	$17 \cdot 15 + 27 \cdot 24$	$= 44 \cdot 59$	"	$8 \cdot 912$	"
3d.	$44 \cdot 59 + 20 \cdot 58$	$= 65 \cdot 17$	"	$13 \cdot 034$	"
	etc.	etc.		etc.	

The strains on the lower flanch are all tensile and produced entirely by the strains on the diagonal compression bars or struts. The strains on the upper flanch are all compressive, and are due to the strains on the diagonal ties; they will be as follows:

Bar.		Strain.		Sectional Area.	
1st.		$= 27 \cdot 44$	tons.	$6 \cdot 86$	sq. in.
2d.	$27 \cdot 44 + 20 \cdot 58$	$= 48 \cdot 02$	"	$12 \cdot 005$	"
3d.	$48 \cdot 02 + 13 \cdot 72$	$= 61 \cdot 74$	"	$15 \cdot 435$	"
	etc.	etc.		etc.	

The strain on the first bar is obviously equal to v when the strain on the first tie is equal to the length of the tie. In Fig. 2, this bar is $a\,b$, for there is no strain on $n\,a$.

It now appears desirable to determine the most economical arrangement which may be given to the diagonal bars of a lattice girder.

We will suppose all the bars to be of equal length; then will the weight of the web be proportional to the sectional area of one bar multiplied into the length of the bar, and the number of bars. Let $v = 2\,z$; then, because the depth of the girder, z, and the diagonal, form a right angle triangle, $\text{L}^2 = z^2 + \text{D}^2$. The sectional area of one bar is proportional to the strain, and therefore to $\frac{\text{L}}{\text{D}}$, and the number of di-

agonals is proportional to the span of the girder $\div z\,\text{D}$. If $l =$ span of the girder, the weight of the web varies as

$$\frac{\text{L}}{\text{D}} \times \text{L} \times \frac{l}{z\,\text{D}};$$

but for any one case l and D remain constant. Hence the weight of the web varies as

$$\frac{\text{L}^2}{z};$$

and for the most economical disposition of the bars this will be a minimum. We will take a series of values for z, D being $= 2$:

$$\begin{array}{lll} \text{When } z = 1, & \text{L}^2 = 5, & \frac{\text{L}^2}{z} = 5{\cdot}00 \\ \phantom{\text{When } z} = 2, & \phantom{\text{L}^2} = 8, & \phantom{\frac{\text{L}^2}{z}} = 4{\cdot}00 \\ \phantom{\text{When } z} = 3, & \phantom{\text{L}^2} = 13, & \phantom{\frac{\text{L}^2}{z}} = 4{\cdot}33 \end{array}$$

Hence the value of z is between 1 and 3. We will take another series:

$$\begin{array}{lll} \text{When } z = 1{\cdot}9, & \text{L}^2 = 7{\cdot}61, & \frac{\text{L}^2}{z} = 4{\cdot}0052 \\ \phantom{\text{When } z} = 2{\cdot}0, & \phantom{\text{L}^2} = 8{\cdot}00, & \phantom{\frac{\text{L}^2}{z}} = 4{\cdot}0000 \\ \phantom{\text{When } z} = 2{\cdot}1, & \phantom{\text{L}^2} = 8{\cdot}41, & \phantom{\frac{\text{L}^2}{z}} = 4{\cdot}0047 \end{array}$$

From this series we conclude that the greatest economy is obtained when $z = \text{D}$; hence our fourth axiom, *the lightest lattice web is obtained when the distance between two successive summits of the same system of triangles is equal to twice the depth of the girder.* The value of $\frac{\text{L}}{\text{D}}$ will, in this case, be

$$= \frac{\sqrt{z^2 + \text{D}^2}}{\text{D}}$$

$$= \frac{\sqrt{2\,\text{D}^2}}{\text{D}} = \sqrt{2} = 1{\cdot}4142.$$

The strain brought upon the flanches by any diagonal except the end ones will be equal to the strain on such diagonal $\times \frac{2}{\sqrt{2}}$, or it is equal to the load carried by such lattice bar $\times \sqrt{2} \times \frac{2}{\sqrt{2}} =$ twice the load carried by the lattice bar.

The strain brought upon the flanch by the last lattice bar $=$ load upon diagonal $\times \sqrt{2} \times \frac{1}{\sqrt{2}} =$ the load upon the diagonal.

Let us work out the strains and the sectional areas for one girder constructed on the above plan, but consisting of two series of triangles, so that one series will sustain half the load on the girder.

Let the span of the girder be 30 ft., the distance between two joints in one series of triangles 6 ft., then the depth of the girder will be 3 ft. Let the load per foot run be ·75 ton. Then, proceeding as before,

$$w' = \frac{w\,v}{n} = \frac{{\cdot}75 \times 6}{5} = 9$$

for the two series, and ·45 for one series of triangles, for which latter

$$\frac{w' \text{L}}{2 \text{D}} = \cdot 318, \text{ nearly.}$$

The strain on, and areas of the diagonal bars of one series of triangles will be:

Bar.		Strain.	Area.
1st.	$\cdot 318 \left\{ 1 + 3 + 5 + 7 + 9 \right\}$	= 7·95 tons.	1·987
2d.	$\cdot 318 \left\{ -1 - 3 - 5 - 7 + 1 \right\}$	= 4·77 "	0·954
3d.	$\cdot 318 \left\{ 1 + 3 + 5 + 7 - 1 \right\}$	= 4·77 "	1·192
4th.	$\cdot 318 \left\{ -1 - 3 - 5 + 1 + 3 \right\}$	= 1·59 "	0·397

and so on. These are, as before, the theoretical areas for an uniformly distributed load. We will now take the strains for maximum loads, considering ·25 ton per foot run the weight of the structure, we shall have,—

Bar.		Strain.	Area.
1st.	$\cdot 318 \left\{ 1 + 3 + 5 + 7 + 9 \right\}$	= 7 95 tons.	1·987
2d.	$\cdot 318 \left\{ -1 - 3 - 5 - 7 \right\} + \cdot 106$	= 4·97 "	0·994
3d.	$\cdot 318 \left\{ 1 + 3 + 5 + 7 \right\} - \cdot 106$	= 4·97 "	1·242
4th.	$\cdot 318 \left\{ -1 - 3 - 5 \right\} + \cdot 106 \left\{ 1 + 3 \right\}$	= 2·44 "	0·428

and so forth. The strains on the flanches may be worked out as before.

From these series we are induced to suspect that in some cases there are certain bars which act both as ties and struts; and this being a point of considerable importance, as will be shown hereafter, we will immediately ascertain under what circumstances this will occur. In calculating the maximum loads upon the diagonals, we are at liberty to consider whichever part of the girder we please as totally loaded, and in some cases we shall by these means find compressive and tensile strains acting occasionally on the same bar; thus, for instance, if we have a girder of 10 triangles, the weight of the structure being w, and that of the live load $2\,w$ per foot run, we have for the strain on the eighth bar,—

$$\frac{3\,w\,\text{L}}{2\,\text{D}} \left\{ -1 - 3 - 5 - 7 - 9 - 11 \right\} + \frac{w\,\text{L}}{2\,\text{D}} \left\{ 1 + 3 + 5 + 7 \right\}$$

$$= -\frac{54\,w\,\text{L}}{\text{D}} + \frac{8\,w\,\text{L}}{\text{D}} = -\frac{46\,w\,\text{L}}{\text{D}}$$

If the load be on the other side of the bar, the strain will become,—

$$\frac{w\,\text{L}}{2\,\text{D}} \left\{ -1 - 3 - 5 - 7 - 9 - 11 \right\} + \frac{3\,w\,\text{L}}{2\,\text{D}} \left\{ 1 + 3 + 5 + 7 \right\}$$

$$= -\frac{18\,w\,\text{L}}{\text{D}} + \frac{24\,w\,\text{L}}{\text{D}} = \frac{6\,w\,\text{L}}{\text{D}}$$

hence we see that, at and near the centre of the span, the diagonals will act sometimes as ties and sometimes as struts. We must, there-

fore, make them sufficiently strong to bear either strain; such variations of strain cannot, however, occur at or near the points of support.

A few remarks are necessary before leaving this part of our subject, —on continuous lattice girders.

In this case we may take the central part of the girder, viz., that contained between the points of contrary flexure, and treat it as a lattice girder of the same span supported freely at both extremities. And the other parts may be treated as semi-beams loaded with an uniformly distributed weight and with a weight at the end, which latter will be equal half the load on the central part of the girder. We may thus give a general rule for this case; bisect the distance between the points of contrary flexure, then the load carried by any strut whose upper end is n triangles from the point of bisection and by the tie to which it transmits the load, will be, w being the load per foot run, and v the length of the base of one triangle, $n\,w\,v$, and the strain on such strut and tie is $\pm\ n\ w\ v\,\frac{\mathrm{L}}{\mathrm{D}}$.

We have hitherto, in every case except one, regarded the web as consisting of one series of triangles, but it more frequently occurs that a number of series are used forming a lattice web; then each series will bear an equal portion of the load. Thus, if the base of one large triangle equals v, in one series there will be a load on each apex equal to $w\,v$; but if there are m series of triangles, the load on each apex will be $\frac{w\,v}{m}$, or we may calculate the areas of the bars as if for one series, and subsequently divide these areas by the number of series of triangles employed. When only one or two series of triangles are used, totally distinct from each other, that is to say, not riveted or otherwise fastened together at the intersections of the diagonals, the girder is termed a triangular girder; but if a greater number of series are employed and riveted together at their intersections, it is called a lattice girder.

Having completed our investigation of the principles of lattice girders, we will make a few observations on the construction of them, particularly as regards the forms of the various elements of which they are composed.

The bars must never be made of less areas than those obtained by the foregoing calculations, and in many instances it will be necessary to make them of greater area.

In triangular girders, the ties may be of flat bars or plates; but all bars which act as struts must be provided with feathers along their whole length, and they may be conveniently formed of angle, **T**, or channel iron, with or without the addition of flat bars, according to the requirements of the case.

In lattice girders, consisting of many series of triangulations, it will not be necessary to make the struts with feathers, and the riveting together of the various lattice bars will make the web sufficiently stiff; but the girder should be provided with standards or stiffening plates

at frequent intervals, in the same manner as an ordinary plate girder, and in fact it requires a greater number of these to render it equally stiff with a plate girder. In triangular girders, the bars will increase in their sectional areas as we proceed from the centre of the girder towards either point of support; but in lattice girders it will be found more convenient to make the diagonals all of the same sectional area, the necessary strength being supplied by using a greater number of series of triangles as we approach the points of support. The number of series of triangles will not alter between two standards, as such an arrangement would be very inconvenient. The diagonals near the centre of a triangular girder must all be made as struts.

Over the points of support, it will be necessary to use very strong standards, or, what will be more convenient, moderately strong standards and a plate web.

Very open triangular girders cannot be made continuous with advantage, for in that case the web of the girder must be very materially altered at and near the points of support. The bottom flanch of a triangular girder may be made as bars or links, if the girder be not continuous; but the top flanch must be rigid, if the girder has a lattice web; or if continuous, both flanches must be rigid.

In triangular girders, the diagonals must be fastened to the flanches by strong pins, or by riveted joints. The latter method seems preferable, as imparting the greatest rigidity. The cross girders should be attached to strong standards, so arranged that the load may come first upon the joints in the top flanch; if otherwise, the calculations must be slightly modified to suit the case, for, when this occurs, the load on the struts will be somewhat different.

For the Journal of the Franklin Institute.

The Garonne, and the works executed upon it under the direction of M. Baumgarten. By Joseph Bennett, Esq.

The following account is made from notes taken some time since, on reading a report of M. Baumgarten, who for eleven years directed the works upon a portion of the Garonne, below the mouth of the Lot, and executed between 1836 and 1847. The steps taken to secure full information as to character of the river, the careful observations of Nature's workings in some mooted questions, and the zealous fidelity in mastering every thing that could throw light upon the subject, is quite interesting, and may, in a measure, serve as a guide for those having similar interests in charge. The report was accompanied with beautiful maps, showing the condition of the river before and after the works, with several elaborate tables, which served as a basis of comparison of the changes in the heights of water due to the works and of the different slopes affected by the river in different stages of water.

Between Agen and the Gironde Department, the Garonne runs through a fertile low plain, submersible for a quite regular breadth

of $2\frac{1}{2}$ miles, its height varying from $16\frac{1}{2}$ to 23 ft. above low water. It has but two bends and three alignments in the $42\frac{1}{2}$ miles; the transverse slope of the low plain is nearly insensible, seldom reaching a difference of 3 ft., and in some cases lower at the foot of the hills than at the shore banks. The mean height above low water is 21 ft., and its slope the same as that of the river.

The free discharge of freshets in this plain is much impeded by *levees*, most generally detached and constructed at the caprice of the proprietors, without the supervision of the government. The levees are more or less submersible, and but a few are raised above highest freshets, thus protecting but isolated properties.

On the left bank, the plain is bordered by hills 147 to 197 ft. above the sea, and at their feet is the lateral canal to Garonne. The two principal affluents, the Ourbise and the Avance, whose valleys are respectively $1\frac{1}{2}$ and 1 mile in width, on entering the plain, rise in the Landes, have a gentle slope, and bear only sand; the other 14 affluents rise in neighboring hills, presenting torrents, and bring down gravel.

These affluents, in coursing the plain, are generally enclosed between two levees, made by proprietors, so that their bed is even with and often above the adjoining plane; in most cases the plain to the right and left of these affluents, is raised from deposits of the streams.

Upon the right bank, between the mouth of the Lot and Tonneins, the range of floods is limited by the hills of Nicole, whose crests are 460 ft. above the sea. Below Tonneins, even to the Medier near Mongauzy, in Department of Gironde, a distance of 19 miles, these hills are separated from the low plain by a high plain having a mean width of 2·1 miles at Marmande, but contracting towards Mongauzy.

The transverse slope of the plain is hardly appreciable, and its longitudinal is the same with that of the low plane and river.

The three principal affluents of the right bank, the Tolzac, Trec, and Gupie, have moderate slopes, bringing down but slime; they make a sensible depression in the portions of the high plain they traverse.

The valley of the Garonne is hollowed out of the tertiary formation, which in this basin is composed of three fresh water deposits, between which are found two marine deposits. The lower fresh water deposit prevails in the Department Lot-et-Garonne, and is formed of alternate layers of clay, of tuffa (composed of small grains of white quartz, and felspar, and mica spangles), and of calc. The clays are very compact, of a white, red, yellow, and green color, having no fossils.

The bed of the river in the portion discussed, is composed of tuffa and clays; in some points the tuffa is exposed in extreme low water; its resistance, and that of the compact clays, limit the undermining, which in some cases, as at the Catalan rock and at Meilhan, are 49 ft. below low water; generally this earth is from 13 to 19 ft. below it, and is covered with a friable layer of gravel.

This first fresh water deposit is covered by the first marine deposit, similar to the calcareous formation in the environs of Paris. It appears only in the hills of the left bank between Avance and Meilhan,

but has a great development in the Gironde Department; from it came the enrockments made in the Garonne below Avance and Couthures.

Above the first fresh water deposit in the hills of the left bank is a layer of gravel, ferruginous, clayey, sometimes 13 ft. thick, which seems to be cotemporary with the great flood which hollowed out the Garonne valley. It is composed of stones from 12 to 15 inches long; it is silicious, with clayey schist and some granite, and is covered with a great thickness of deluvium. This gravel is not found in the hills upon the right bank, though they are 130 ft. higher than those on the left, and it is only found upon the high plain spoken of, and seems to have been deposited there in the formation of the valley by the washings from the left bank. The gravel of the low plain is finer than that on the left bank. In the lower part of these gravel deposits are found tusks and molars of elephants.

The low plain is the work of the actual régime of the Garonne, produced by the alluvion of the river, which, if free, would occupy the whole breadth of 2½ miles. This modern alluvium is from 33 to 39 ft. deep, alternating with sand, gravel, and silt, according to the velocity of the current which deposited it.

The nature of the gravel banks now transported by the Garonne is the same as that of the banks forming the summit of the hills of the left bank and the high plain of the right.

Windings and Variations in Bed of River.—Though the bed of high water has but one bend at Tonneins, the low water has twenty-one in the same extent so sharp that their radii at Tonneins, Meilhan, and Jusix, are respectively 338, 261, and 327 yards, making tangential angles 50°, 80°, and 40°. Thrice it touches the hills at Nicole, Tonneins, and Marmande on the right, and three times on the left bank, at Mas, Caumont, and Meilhan; thus a developed course of the mean bed shows a length of 33½ miles, while the corresponding part of the low plain has but 23 miles, or 68 per cent. of the former. This lessens the slope and velocity of water and increases the depth and ease of navigation.

The Garonne, acting freely, incessantly displaces its banks and encumbers its bed with the gravel deposits of its corrosions; giving birth to islands, which the works have partly caused to disappear; they all commenced as simple gravel banks, which, as they increased, were covered with a spontaneous growth, and so extended by the hand of man, they become powerful agents in the corrosions of the opposite banks.

From a comparison of ancient plans as far back as 1785 with those of 1827 and the actual condition of things in 1848, it appears in some places that the banks have stood intact for over 60 years without defences; in other places, as at the gravel bank of Sérénat, above Tonneins, the right bank has receded over 545 yds. from 1785 to 1827, or in 42 years has nearly completely shifted three times its ordinary bed. Other instances are recorded, showing great irregularities of progress; the greatest, those of Col-de-Fer and Fourques, not exceeding 16 to 17

yards per year; while at the Isle of Balias, Latuque, and Sainte-Bazeille, the corrosions were as a mean from 4 to 5 yards per annum.

From a careful study of charts showing the successive states of the banks, we do not always find, as indicated by theory, an alluvion in the rear of the convex part, which follows the concave corroded portion; for when the corroded bank is formed of silt, clay, and sand, the water holds them in suspension, and in a great freshet may bear them to the sea. The theory is only confirmed when the corroded banks are composed of gravel too heavy to be far removed. Some corrosions occur only in time of mean low water; they are caused by oblique gravel banks, which turn the currents against the opposite banks to undermine their base; other corrosions are due to the violence of direct currents in high water; but the greatest number arise from the sinking and sliding of the banks two or three days after the waters of a great freshet have returned to their bed, the earth being well soaked, after a long submersion, and urged forward by the water which finds a subterranean passage to the river, ends with a sinking of the banks. In this way towing-paths, which seemed in good condition the day after a freshet, have entirely disappeared three days afterwards.

The width of the bed is very irregular at low water; it may be between 76 yards, as at the Balias Isle, and 327 yards, as at the Isle of Meyniel; in mean water the width varies between 185 and 380 yds.

Movements of Gravel, Sand, and Silt.—The movements of materials may occur in three ways: 1st, when, by the limited velocity of current or the size of the material, it can only be borne discontinuously in rolling upon the bed. 2d, when the velocity is great and materials small, so as to be easily borne a considerable distance, though always in a discontinuous manner and without leaving the lower portion of the current. 3d, when the material is so minute as to be held in suspension, and may run continuously with the water for any distance. These three types represent the usual effects occurring in nature, though there may exist intermediate movements.

The materials of the first type are borne but a short distance; they are urged along a plane which rises in going down stream; at the end of this incline they find a greater depth, into which they fall, maintaining a steep slope; there they remain till covered by fresh accessions.

The division between this inclined surface and steep slope is marked by a salient edge, more or less inclined to the current, and which progresses from above downwards; this disposition is well seen in low water upon the great banks which were in motion during a freshet. The progress of one gravel bank above the Col-de-Fer was measured. In 1839, the edge commenced forming; in 1840, had acquired, on the lower slope, a height of 1·4 yards to a base 3 yards, and a length of crest 196 yards; in 1841, its form was nearly the same, having 1·37 yards height to 3·9 yards base, and had advanced parallel to itself 33 yards; in 1842, it had passed 22 yards lower, and in 1843, the sands below this slope were brought to a level. The original surface,

over which the gravel rolled, was not a plane, but convex with a constant form, the 29 yds. preceding the crest having a slope of ·046 ft. per foot, and upon the 29 yards below of ·062 ft.; the gravel was generally the size of a hen's egg, and the requisite velocity of the water to move them might be from 2 to 2·7 yards. The same thing occurs upon the banks which are not bare in low water, for in sounding the channel, wherever there has been a gravel movement, the depths decrease, going down stream till they arrive at a crest, where succeeds a depth 3 to 4 yards greater, in which whirls are formed with a horizontal axis parallel to the crest, and are designated as "foudres" by the navigators.

The gravel banks are often prolonged under the water to connect with those that lay bare, forming the two banks of the river; the crest then crosses the river obliquely and forms a bar. In high water the gravel raises this crest, thus forming a dam for low water; but this dam causes rapids and an excess of velocity, which dig out trenches across the crest and bear the gravel beyond the slope; so that, in a sudden fall of high water, the boats find a less depth in the passes, even with a large delivery, and some time after in low water these passes have not over ½-yard of depth.

The sand itself acts in this way when deposited in the secondary arms, which have a small velocity and tend to fill up.

The general movement of the gravel banks is much below 26 yards per annum, and this amount is attained only in marked changes of the bed, from corrosions of banks by works constructed in the usual bed, or in the submersible plain, tending to increase the velocity and destroy its former equilibrium.

It is certain that some gravel banks in the middle of the bed, and from 2½ to 3 ft. above low water, though subjected to the strongest currents, are not borne away by them. To prove this, in Nov., 1845, pieces of wood from 12 to 15 ins. long and 7 ins. diameter were sunk from 6 to 12 ins. in four places where the current was very strong; the surface of gravel and tops of sticks were compared with the level of nails upon the neighboring piles of the works. In Aug. 16th, 1846, three were found in the same place and the gravel was at the same height; the fourth, that found above Coussan, had been carried away, but the oak branches which had been placed along side of them, for the purpose of retracing the locality, though broken at the surface and laid horizontal by violence of water, were still attached to the stem fixed in the ground, and showed no marks of attrition, which must have been the case had the bed been obstructed by gravel driven by the water. The gravel banks of the Garonne, composed of pebbles two to three inches long, may thus be said to have but little movement at the present time. They have been formed from gravel deposits of a remote period, and, laying at a great height above the highest freshets, and are not brought down from the mountains at the present time, for then the bed of the river would be raised, but upon a great number of points, the water runs, not upon gravel, but upon the tuffa, clay, and rocks of the tertiary earth of the valley.

2d. The small gravel and sand of all dimensions form another portion of the bed and apply to the second adopted type of movement; they are generally mixed 20, 30, and 40 per cent. with the gravel, but in times of strong currents are separated and borne at great distances, surmounting the dams, lines of work, and banks, to be deposited in the first slack water; but generally these materials are too heavy to be borne continuously, and a freshet often deposits it at the height of 3 or 4 yards, either in secondary arms or in slack water behind the lines of work, and in eddies, but never in the channel proper.

These two modes of movement are heard on plunging a stick into the water.

3d. The slime brought down by torrents and affluents of all kinds after rain, generally finds its way to the sea, and only is deposited along the way in places where the velocity is insensible. It is this which fertilizes the alluvion; it may be in heights from 15 to 20 ins. per annum. That coming from the Tarn has a red chocolate color, from the Aveyron it is black, white from the Pyrenees.

Slope.—The leveling of the slope of an extended stream is quite a delicate matter, by reason of the variations in the heights of water, and because the partial and local heights of low water are by no means parallel to those of the mean and high waters.

The piles of the submersible dykes of the works, also piles driven on top of the bank behind the tow-path at every 500 metres and opposite the stone post marks, were used as benches. The pile benches were generally at 109 yards apart; careful levels gave their height above the mean level of the sea. On a given day and at a determinate height of water, the height of these bench nails was determined in the shortest possible interval of time. An iron rule $6\frac{1}{2}$ ft. long, turning upon a hinge of an iron pillar secured to the head of the pile by a quarter collar and thumb-screw, was used for taking the measures. The rule was leveled by a spirit-level, and a cord with a copper bob at the end was let slip through a groove at end of ruler till it touched the surface of the water, and the distance was measured directly upon the ruler.

The length of the ruler enables one to measure outside of the small eddies in neigborhood of pier.

In 61,109 yards there were placed 584 benches, and 4 operators, each furnished with a rule, could take all the heights in a day, each having charge of 146 benches in a distance of 8·68 miles.

Thus with little cost exact levels were taken every year for different heights of water, whenever the bench nails (usually from 7 to 10 ft. above low water) were uncovered; for greater heights of freshets, the 10 road laborers for maintaining the tow-path marked upon the 500 metre stone marks the highest water, either by stakes or cuts on poplars planted for this purpose near them; the levels were then connected with the bench marks by the two navigating overseers.

As far as possible, the delivery was gauged each day of the leveling.

With these data of slope, height of water, and delivery carefully gathered in a long series of years, during which either the mean bed

or the bed of low water had been changed by the works of navigation, or the larger bed by dykes upon the plain, it was easy to solve the problems relative to the changes by these works upon the régime of the river.

Profiles were made of all these levels, and, the better to compare the slopes, a new profile of the levelings was made for each year, deducting from each the corresponding height of water of the scale of Tonneins diminished by one metre; or, in other words, all these lines of slopes were carried parallel to themselves, and made to pass through the same point at 1 metre above zero of the scale at Tonneins.* A mean straight line between all these curves gave the mean slope of water for the 34·6 miles in question. This line took a slope of 0·26525 ft. per 1000 ft.

This fictitious mean slope, around which oscillate the real slopes at different heights, admits of a better appreciation of their inequalities and variations.

We pass over the comparison of the low water (0·62 m. Tonneins scale) slope, with the details of its maximum and mean departures from the mean slope, showing at that stage 12 reaches with a mean slope of 0·119 feet and 12 rapids with a mean slope of 1·020 feet per 1000 ft., to say, that with the rise of water, these inequalities tend to disappear; for with the water at 2·6 m. (same scale) there were but five rapids. A comparison of the two curves of 0·62 m. and 2·60 m. shows that scales placed at the stations 86·3 k. and 104·5 k., so as to coincide when the water stood at 0·62 m. (Tonneins scale), disagreed 1·36 m. when the water stood at 2·60 of the same scale.

With the water at 5·57 m. at Tonneins, the slope became generally quite regular, properly speaking, without rapids, and the variations were due rather to the contours of shore banks, in horizontal projections, than to inequalities in the bed of the river. A comparison of it with 0·62 m. depth would show for two scales at stations 55 and 95, coinciding at the latter depth, a discrepancy of 1·97 m.

The freshet of February, 1846, which stood at 7·02 m. at Tonneins, had a nearly parallel slope with the curve of 5·57.

Transverse Profile.—Some engineers have thought that the water cambers in the middle, when it is rapidly rising, and that it becomes concave on the falling of the water. Eleven careful levelings were made near the mouth of the Avance, in a straight portion of the Garonne, unaffected by any centrifugal force, and between the hours of 10·45 A. M. and 5·15 P. M., at a time when the water was falling rapidly, and when it stood 5·80 m. on Marmande scale; during the fall of 2 feet in $6\frac{1}{2}$ hours, the experiments showed no sensible difference; for as a mean, there was only a depression at the left bank of 0·065 feet below the right, the middle being 0·042 feet above the left, and ·023 feet below the right.

Some time after, the water standing at 3·90 m. on the same scale, observations were made in the same place, when the water was rising;

* To compare the changes made in the slopes by reason of the works, it was necessary to compare the slopes of the different years, reduced by calculation to one same height for a scale, where the water plane had not varied, and this arbitrary point was chosen as suited to that purpose.

the mean of nine observations made between 10 A. M. and 5½ P. M., gave the middle as 0·367 ft. above the right bank, and ·082 above the left. It was thought, however, that these observations, to be conclusive, should be often renewed, and in different localities; unfortunately, all was not ready at the fit time, and at another trial the fixtures were broken by a descending boat.

At Tonneins, in a great freshet, the centrifugal force raised the water 1·3 ft. against the left bank, at the summit of the concave bend.

Depth of Water in middle of River.—Soundings were made in 1836, when the works had but little affected the natural bed of the river. We omit the details, which show great inequalities of shallows and deeps. Most generally a shallow is found when the current changes its bank, excepting when the upper concavity is protected from corrosion. In low water, the greatest velocities correspond to shallows, and the reverse in high water. The cause of the irregularities of low water bed is to be found in the section and direction of the larger bed, and in the action of freshets upon them. When the high waters are accidentally directed towards a single point, either by dykes, or natural courses, such as in bends against insubmersible hills, great velocities are formed at the bottom, which dig out the bed, and deposit the gravel at the outlets of these passes.

Heights of Water.—We have seen that the different scales, though all referred to low water, differ among themselves; it was then important to choose one not subject to these anomalies, nor to changes in level produced by the works. Gaugings were made at different periods, at same heights of water, which prove that the plane has not varied at Tonneins; so that this scale was adopted. A table was made, which gave as a mean of 15 years, from 1832 to 1847, the number of days at which the water was held at different heights. Calling low water all below 3·28 ft., mean water between that and 7·28 ft., high water between that and 17·7 ft., and freshets all above that, there are for the 15 years—

69	days of	low water.
145	"	mean "
142	"	high "
9	"	freshets.

Or 287 days of good navigation; or, as navigation is not actually impeded except when the water is below 2 feet, which may happen for 22 days, there may be said to be 334 days of good navigation.

Calling the mean height of water that obtained in adding all the heights observed at noon, divided by the number of days, there is 7·28 feet for the mean of 15 years; the mean height of each month was given, and the table shows that the melting of snows is not the prevailing cause of high water. The highest freshets are recorded as far back as 1712. One of 1843 passed through 71·3 miles in 24 hours, showing a velocity of 4·16 feet per second, or one-half the velocity proper of the river. It would seem that the velocity of propagation of a freshet depends on its being instantaneous, rather than upon its elevation.

Every two or three years the navigation is impeded by floating ice, though the river is rarely frozen over, and but once between 1833 and 1848; on the breaking up, many lines of work, not well grounded, were overthrown, and some piles sawed and cut in two by ice. Thermometrical observations were made at the request of M. Prouy, the seven hours of morning, at noon, and seven hours of night; they were only continued from December until May, when the instruments were broken. From these it appears that at night and morning the water is warmer than the air, and the reverse at noon; that in the nights of winter months the water does not grow cooler, while in the spring it is 1·5° (Cent.) cooler in morning than evening.

Delivery —A great number of gaugings were made with Woltmann's mill; in depths of 13 to 16 ft. the velocities were easily measured; in some freshets the velocity was measured in depths of 26 to 29 feet, though with considerable difficulty. In some places velocities were measured in 40 points upon a surface of 119 sq. yards. A table of 24 gaugings, with heights between 0·48 m. and 7·40 m., gave from 110 cubic metres up to 3664 cubic metres.

These results were co-ordinated by an empirical formula, similar to that of Lombardini for representing the delivery of the Po. Calling Q the delivery, h the height of water, and p the slope, the formula is

$$Q = m\, h \sqrt{\rho}.$$

m being a constant co-efficient for the same river.

For heights $h = 1{\cdot}40$ m.; 2·70 m.; 6·50 m.; 9.

The corresponding slopes per kilometre were

$\rho = 0{\cdot}11$ 0·19 0·21 0·42;

which gives the relation,

$$\rho = -\,0{\cdot}094 + 0{\cdot}201\, h - 0{\cdot}044\, h^2 + 0{\cdot}003\, h^3.$$

Making $m = 125$, it represents to within $\frac{1}{20}$ the 17 deliveries, with heights below 6·4 m.; beyond that its results are too great. An inspection of the curve shows that with equal heights of water, the delivery is greater when the water rises than when it falls.

From this table we have the mean delivery per second for each month and year; the mean annual delivery from 1832 to 1847 was 863 yards per second, answering to a height of 2·36 m. Lombardini terms this quantity the *modulus* of a river, which for the Po was 2249 yards; the months of August and March answer as a mean to the maxima and minima of monthly delivery.

The mean volume per year, if supposed extended over a length of 34·7 miles and a breadth of 2·5 miles, would have a height of 305 ft., answering to a cube with a side of 3603 yards. The velocities increase with the height from 3·77 feet at 0·48 m. (Tonneins scale) to 10 feet at a height of 6·45 m.

Silt—The silt, constantly held in suspension by the Garonne, is the great fertilizer of the rich vegetation teeming along its banks. Each day a quantity exactly measured was taken from the surface, allowed to settle from 8 to 10 days, decanted, and weighed; a number of ex-

periments, made with assortments from surface to a depth of 29 feet, shows an equal distribution, and warrants the application of the surface to the whole mass. Multiplying the weight of silt per cubic yard by the whole delivery, for the space of 8 years, there were 408 lbs. per second for a delivery of 1030 yards, or 0·39 lbs. per cubic yard. For the five years, from 1843 to 1848, when the deposits were somewhat greater, there was 0·47 lbs. per cubic yard; its mean density was 1·47, and 533 lbs. answers to a volume of 0·215 cubic yards; so that the total deposit per annum, well settled and dried, as a mean of five years, would give a cube of 226 yards a side, and would have risen on a plane of 34·7 miles by $2\frac{1}{2}$ miles 0·076 feet.

Meteorological Observations.—On a comparison of annual heights of rain-fall from 1833 to 1816, which as a mean was 2·39 feet, with annual delivery of river, there is an evident correlation; and the great freshets for some time back upon the Loire and Rhone, must rather be attributed to the abundant rain-fall than to the clearing of the mountains. The end of the last century was more noted for high freshets upon the Garonne than later years, though there are more lets and hindrances from levees and dykes to the full sweep of floods, and though the mountains are more cleared and cultivated.

The volume of water delivered by the Garonne for 14 years, was 0·646 of the whole rain-fall.

(To be Continued.)

The Victoria Bridge at Pimlico.

From the London Engineer, No. 279.

It is rumored that both the roadway and the piers of this structure, completed a few months ago at a cost of nearly £100,000, are exhibiting signs of weakness. This bridge has, besides a number of short spans in the approaches, four wrought iron segmental arches of 175 ft. span each, there being three piers in the river. After the completion of the work, the piles, we believe, which had served as an enclosure to the piers, were withdrawn, leaving the foundations of the bridge exposed to the scour of the river. From the nature of the bottom, we should suppose that all the protection which the original piles (sawn off below water) could have given, would have been necessary. The arches themselves are formed each of six wrought iron plate ribs, arranged in three pairs, two pairs being placed so as to form the outsides of each span, while the other pair extends along the centre. These arched ribs are each about 4 ft. deep, and, perhaps, $\frac{1}{2}$-in. thick, although they do not appear to the eye to be more than $\frac{3}{8}$-in. thick. Flanches are riveted on both top and bottom. The spandrils are made of T-iron, riveted together in a sort of lattice-work. Over the spandrils, horizontal plate beams are placed, with their upper surfaces level with the crown of the arch, so as to complete the horizontal line of the roadway. The latter is carried upon rolled wrought iron cross beams, each about 11 ft. long, and 9 ins. deep, and spaced about 3 ft. apart. The ends of these beams abut

against the inner vertical surfaces of the arched ribs and horizontal beams over the spandrils. The fastening of these ends to the ribs is one of the most wretched "cobbles" to be found in bridge construction. First, a short piece of angle-iron, its upper horizontal surface forming a projecting shelf, about 4 ins. long and 3 ins. wide, is riveted by four rivets to the main arched rib (or to the horizontal beams over the spandrils). On this shelf, the end of the cross-beam rests. The form of this beam, in section, is like that shown in Messrs. Mather, Ledward, and Co.'s card in our advertising columns. Two short vertical lugs, formed also of angle-iron and riveted each by three rivets to the main rib, embrace the "stem" or thin vertical part of this beam. Through these lugs and the "stem" of the beam three rivets are inserted. The ends of the beams, therefore, hang by three rivets besides resting on the short projecting flanch of a fragment of angle-iron below. Instead of buckle-plates, blocks of creosoted wood are wedged between the cross-beams, and over these is the ballast and permanent way.

MECHANICS, PHYSICS, AND CHEMISTRY.

On the Composition of Cast Iron and Steel. By M. E. Fremy.

From the London Chemical News, No. 74.

I have already shown* that iron, cast iron, and steel do not appear to me to be allied, in relation to their composition, as is generally admitted; and it is not correct to say that steel is simply a combination of iron and carbon less carburetted than that forming cast iron.

Without absolutely denying the influence exercised by carbon on the properties of steel and cast iron, I purpose nevertheless to show that several other metalloids possess the property of greatly modifying the characteristics of cast iron and steel, and that these bodies do not exist accidentally in these compounds; and that all the uncertainty connected more especially with the manufacture of steel may probably be traced to the action, hitherto little studied, of foreign bodies.

The object of the experiments which I now make known is to determine the conditions under which nitrogen can combine with iron.

Every chemist is aware that to M. Despretz we owe the important discovery of nitride of iron; to him we owe the demonstration that iron, at red heat, decomposes ammoniacal gas, fixes the nitrogen, becoming itself white and brittle, and augmenting in weight, sometimes to the extent of 11·5 per cent. Submitted to the action of acids, this body produces a salt of iron and an ammoniacal compound.

These clear results have, however, been doubted by some chemists. Some have thought the increase in the metal's weight was owing to an oxidation produced by the water or air which ammoniacal gas is capable of retaining; others, that the modifications of the physical properties of the iron were due to an alternate phenomenon of the oxidation

* See Jour. Frank. Inst., 3d Series, Vol. xli., p. 239.

of the metal and the reduction of the oxide by the hydrogen of the ammonia.

Though convinced that the experiments of M. Despretz have no need of confirmation, I wished, however, to repeat the contested experiments in eliminating all sources of error which could arise from impurity in the ammonia or the humidity of the gas. I feel it incumbent upon me to state that every trial has completely confirmed M. Despretz's position. In numerous experiments I have invariably seen red-hot iron decompose ammoniacal gas, producing the brilliant white body called "nitride of iron" by M. Despretz.

The opinion has been advanced that the product of the decomposition of ammonia by iron might be a combination of metal with a hydride of nitrogen less hydrogenated than ammonia.

This question must be decided by experience. In fact, under the influence of oxygen, the compound studied by M. Despretz produces peroxide of iron. In conducting this decomposition in a porcelain tube, communicating with the tubes designed to fix the water produced by the reaction, it is easy to distinguish whether the compound was a nitride or an amidide of iron.

This experiment has been made with the greatest care. A known weight of the nitrogen compound was made red-hot in a current of oxygen, the metal was transformed into pure peroxide of iron, nitrogen was disengaged, and the tubes for absorbing the water underwent no alteration in weight. This experiment appears to me conclusive, and proves that the body produced by the action of ammoniacal gas on iron is actually nitride of iron, and that it contains no hydrogen.

This essential point being once established, it became necessary to determine under what other circumstances iron would combine with nitrogen.

I have first examined the action of pure nitrogen on metallic iron. The nitrogen was obtained either by decomposing nitrite of ammonia, or by the action of copper on atmospheric air, and the gas was purified and dried by the most efficacious means. It results from these experiments that nitrogen combines with great difficulty with the iron prepared by the processes usually employed in manufacture, but that it unites with the metal when presented to it in a nascent state. Thus, I have obtained nitrogenized iron by making nitrogen impinge on the oxide of iron at the moment of its reduction by either hydrogen or charcoal.

Cyanogen also modifies the properties of iron; but I have reserved the study of this reaction for another paper, to be devoted to the study of the phenomena resulting from the combined action of nitrogen and carbon on iron.

The processes to which I am about to refer doubtless yield nitride of iron, but the reactions are slow and incomplete. Thus, completely to nitrogenize small fragments of iron wire by ammonia, I have been obliged to pass the current of gas over the red-hot metal for three entire days.

In order to submit nitride of iron to a thorough chemical examina-

tion, and, above all, to study what influence this body is capable of exercising on the constitution and properties of steel, I have been obliged to devise a new method, which enables me to prepare this metallic nitride with facility. I have been so fortunate as to arrive at this result by decomposing at red heat protochloride of iron by dry ammoniacal gas. I introduced into a porcelain tube about 200 grammes of anhydrous protochloride of iron. This tube I made ret-hot, and passed over the salt a current of ammoniacal gas, furnished by ordinary liquid ammonia, slightly heated, the gas being dried by passing through long tubes filled with caustic potash.

Under the influence of ammoniacal gas the metallic chloride decomposes rapidly; chloride of ammonium and a curious amide salt are disengaged. This salt is instantly decomposed by water, producing ammonia and oxide of iron. After the operation an inflated and partly melted mass is found in the tube; it is sometimes gray, and often also metallic, white, and brilliant. This body is nitride of iron.

I submit to the inspection of the Academy about 200 grammes of nitride of iron obtained in this way. This body, till now hardly known to chemists, can henceforth be prepared with the greatest facility. It will, I have no doubt, become a new and valuable adjunct to our researches, by furnishing nitrogen to mineral substances or organic bodies. This process for the production of nitride of iron applies to the preparation of other metallic nitrides. By the same method I have obtained combinations of nitrogen with the metals of the iron group. A special paper will be devoted to these compounds.

I have proved that nitride of iron, proceeding from the decomposition of protochloride of iron by ammoniacal gas, possesses all the properties of that obtained by passing ammoniacal gas on red-hot iron.

This nitride is easily reduced to powder; it is less oxidizable than pure iron; it is very slowly attacked by nitric acid, but very speedily by sulphuric and by hydrochloric acids.

Nitride of iron when dissolved in acids produces ammoniacal and ferruginous salts.

According to the experiments made at my request by M. E. Becquerel, nitride of iron becomes magnetized readily and permanently like steel, only this property appears less developed than in ordinary steel.

Nitride of iron is remarkable for its fixity, and, in this respect, is allied to nitride of titanium, which has been so carefully studied by MM. Wöhler and H. Deville; in fact, it may be made red-hot without undergoing decomposition. Oxygen attacks it only at a high temperature, and then transforms it into peroxide of iron.

Nitride of iron, when heated in a charcoal fire, undergoes an important modification, to which I must revert when treating of the chemical constitution of steel. It is transformed, in this case, into a metallic mass analogous to steel, and, like it, becoming very hard by tempering. If nitrogen is present in this new compound, it does not exist in the same state as in nitride of iron; for when the hardened product is heated in a hydrogen current no trace of ammonia is disengaged.

The most remarkable reaction of nitride of iron is that which it exercises on hydrogen. When slightly heated in this gas it decomposes immediately, yielding ammonia, and leaving a residue of pure iron.

This direct combination of hydrogen with the nitrogen contained in a metallic nitride appears to me a very curious fact. It, however, proves that nitride of iron can be employed to yield nitrogen to other compounds. The easy decomposition of nitride of iron by dry hydrogen has enabled me to determine the different circumstances in which iron can unite with nitrogen. This experiment, in fact, removes all doubt.

It would be otherwise were the nitride attacked by an acid and the liquid then decomposed by potash. Reagents, and especially potash, often contain nitrates which, under the influence of protoxide of iron, produce ammonia.

The action also of hydrogen on nitride of iron has enabled me to analyze this compound readily. To determine the composition of nitride of iron, it is necessary only to estimate the loss this body undergoes when heated in dry hydrogen.

It results from my analyses that nitride of iron obtained by means of protochloride of iron contains 9·3 per cent. of nitrogen, this composition corresponding to a nitride represented by the formula Fe_5N. By making ammoniacal gas react on iron, M. Despretz has proved that the weight of the metal augments sometimes as much as 11·5 per cent.; the nitride formed in this case would be represented by Fe_4N.

I shall not now dwell upon the formula of nitride of iron, for there is no proof that this compound has yet been obtained in a state of absolute purity; the temperature at which it is formed and the hydrogen atmosphere then surrounding it are capable of varying its composition. It is, however, to be presumed that iron can unite with nitrogen in several proportions, as is shown by the following experiment:—Submit to the action of ammoniacal gas for twenty hours some small red-hot cylinders of pure iron, sufficiently large to render the chemical action incomplete, and the weight of the metal, under these circumstances, does not augment more than 6 per cent.

After this experiment, the metallic cylinders, when examined, will be found to be composed of two very different parts: the external one almost melted, exceedingly friable, and may be detached by the slightest blow; the other, internal, rather hard, and still metallic. The external part is formed of 9·8 per cent. of nitrogen and 90·2 per cent. of iron, corresponding to the formula Fe_5N. Thus, the nitride produced by the action of ammoniacal gas in excess on iron has the same composition as that resulting from the decomposition of protochloride of iron by ammonia. The internal and still metallic portion can be cut by a file; it is, nevertheless, very brittle, and contains nitrogen, but in much smaller proportion than in the preceding. It presents, in its general aspect, a certain analogy with metal called in the foundries burnt iron.

It would be a curious circumstance to ascertain whether this acci-

dent of its manufacture which deprives iron of all its useful properties is not owing to a combination of iron and nitrogen. This is a point not to be neglected in my future researches.

Such are the new facts relative to the history of nitride of iron which I wish to make known to the Academy. I will sum them up in a few words:—

1. The object of my first experiments was to reproduce and prove the exactness of the experiments M. Despretz has described in his paper on nitride of iron.

2. I then established the fact that the body produced by the reaction of ammoniacal gas on red-hot iron is really nitride of iron, and not of amidide; it contains no hydrogen.

3. It results from my experiments that the direct combination of nitrogen and iron takes place chiefly when the metal is in a nascent state.

4. I have proved that nitride of iron is formed with the greatest facility by decomposing anhydrous protochloride of iron by ammoniacal gas. This method applies to the preparation of other metallic nitrides.

5. The composition of nitride of iron prepared by the action of ammoniacal gas either on iron or on protochloride of iron, is the same; it contains about 9·5 per cent. of nitrogen, and may be represented by the formula Fe_5N.

6. Nitride of iron is completely modified when heated in a charcoal fire; is no longer decomposed by hydrogen; and appears to resemble steel.

In another Memoir I shall ascertain whether nitride of iron can be employed in the preparation of steel.—*Comptes Rendus.*

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By Chas. H. Haswell, Civil and Marine Engineer.

No. 9.

(Continued from vol. xli, page 408.)

Torsional and Detrusive Strength.

Torsional Strength.

The torsional strength of any square bar or beam is as the cube of it side, and of any cylinder as the cube of its diameter. Hollow cylinders or shafts have greater torsional strength than solid ones containing the same volume of material.

The torsional angle of a bar, &c., under equal pressures will vary as the length of the bar, &c. Hence, the torsional strength of bars of like diameters are inversely as their lengths.

The strength of a cylindrical prism compared to a square is as 1 to ·85.

When a bar, beam, &c., having a length greater than its diameter,

is subjected to a torsional strain, the direction of the greatest strain is in the line of the diagonal of a square, and if a square be drawn on the surface of the bar, &c., in its primitive form, it will become a rhombus by the action of the strain.

Tables of the Torsional Strength of Materials.

Deduced from the Experiments of Major Wade, U. S. A., and Reduced to an Uniform Measure of

One Inch Square or in Diameter, Weight or Stress applied at one foot in Length from Centre of Axis of the Material, and at the Face of the Axis or Journal.

Section of Figure.	Side (S).	External diameter.	Internal diameter.	Length of journal, or part acted on.	Area of section.	Breaking weight of figure.	Breaking weight per inch, diameter or side.
	Inch.	Inch.	Inch.	Inch.	Sq. inch.	lbs.	$W \div S^3$
Square, . .	1·	1·		3·	1·	730	730
" .	1·415	1·415		3·55	2·	1916	677
" . .	1·750	1 750		4·80	3·	4500	839
Cylinder, .	1·135			3·	1·	896	613
" . .	1·595			3·60	2·	2790	687
" .	1·955			4·80	3·	4750	636
							$W \div (S^3 - S'^3)$
Hollow cylinder,		1·300	·650	3·35	·995	1083	564
" "		1·811	·906	3·60	1·012	3104	597
" "		2·261	1·280	4·60	1·931	5104	540
" "		1 415	·839	5·60	1·967	1302	580
" "		2·211	1·544	5·75	2·728	4125	579
" "		3·250	2·605	8·00	2·926	7916	475

Summary of Preceding Results.

Area of cross section.	Breaking weight of figures.					
	Square $b\,d^2$.	Cylinder d^3.	Area of section.	Hollow cylinder $d^3 - d'^3$.	Area of section.	Hollow cylinder $d^3 - d'^3$
Inch.	lbs.	lbs.	Inch.	lbs.	Inch.	lbs.
1	730	613	·995	563	1·012	585
2	677	698	1·931	597	1·967	579
3	840	636	2·728	540	2·966	476
Mean,	749	649		567		547

All of the bars were from the same mixture of common foundry iron, of a mean torsional strength of 644 lbs. per square inch of section.

From these results it appears that solid square shafts have about one-fifth less strength than solid cylinders of equal areas.

The stress which will give a bar a permanent set of $\frac{1}{2}°$, is about $\frac{7}{10}$ths of that which will break it, and this proportion is quite uniform, even when the strength of the material may vary essentially.

The strongest bars give the longest fractures.

Wrought iron, compared with cast iron, has equal strength under a stress which does not produce a permanent set, but this set commences under a less force in wrought iron than cast, and progresses more rapidly thereafter. The strongest bar of wrought iron acquired a permanent set under a less strain than a cast iron bar of the lowest grade. The mean *values* of cast and wrought iron and bronze, for bars of small diameters for a permanent set of $\frac{1}{2}°$, are as 1·, ·6, and ·33.

TABLE *of the Torsional Strength of Cast and Wrought Iron and Bronze, with their Values for different Diameters.*

Length of Journal, or of the Bar or Beam submitted to strain, for which the Values are given, three times the Diameter or Side of the Shaft.

FIGURE.	Specific gravity.	Length of journal or side.	Breaking weight.	Value for diameter of 2 ins.	5 ins.	10 ins.	15 ins.
		Inch.	lbs.				
CYLINDER. CAST IRON.							
Good common castings,	7·180	8·	583	170	115	105	100
" cold blast, mean of 8 trials,	—	8·	705	175	120	110	105
Gun iron, small bars.	7·320	8·	750	190	130	120	115
greatest extreme,	7·724	8·	833	200	135	125	120
CYLINDER. WROUGHT IRON.							
Begins to yield, permanent set,	7·855	8·	300	130	128	125	123
Bends without breaking,	—	8·	642				
CYLINDER. BRONZE.							
Begins to yield, permanent set,	8·710	8·	192	55	45	35	33
Bends without breaking,	—	8·	458				
SQUARE. CAST IRON,	7·200	3·	730	220	150	140	134
"	—	4·8	840				
" WROUGHT IRON,	7·855	3·	—	170	165	160	162
HOLLOW CYLINDER. "							
Diameters, 1·3 and ·65,	—	3·35	1083	163	110	100	96
" 2·26 " 1·28,	—	4·60	5104	153	105	96	92
" 3·25 " 2·60,	—	8·	7916	135	90	83	80

The experiments above given were made with bars not exceeding 2 inches in diameter; the relations given, therefore, do not hold, as the diameters are increased, in consequence of the shrinking of the cast metals in cooling, which by cooling at the outer surface first, draws the metal from the centre and in effect gives to a bar or shaft the properties of a hollow cylinder. In shafts of 10 inches in diameter, the torsional strength of wrought iron is considered fully equal to that of cast iron, and with larger diameters it would be much greater but that it suffers deterioration as its diameter increases, from the increased difficulty in effecting welding and the reduction of the metal to a fibrous texture.

The following rules in all instances are purposed to apply to the diameters of the journals of shafts, or to the diameter or side of the bearings of the beams, &c., where the length of the journal or the distance upon which the strain bears, does not greatly exceed the diameter of the journal or side of beam, &c., *hence*, when the length or distance is greatly increased, the diameter or side must be correspondingly increased.

To ascertain the Torsional Strength of Square or Round Shafts, &c.

RULE.—Multiply the *value* in the preceding tables by the cube of the side or of the diameter of the shaft, &c., and divide the product by the distance from the axis at which the stress is applied in feet; the quotient will give the resistance in pounds.

Example.—What torsional stress may be borne by a cast iron shaft of the best material, 2 inches in diameter, the power being applied at 2 feet from its axis?

$$125 \times 2^3 = 1000 \text{ and } \frac{1000}{2} = 500 \text{ lbs.}$$

To ascertain the Diameter of a Square or Round Shaft, &c., to resist Torsion.

Rule.—Multiply the extreme of pressure on the crank pin, or at the pitch line of the pinion, or at the centre of effect on the blades of the wheel, &c., that the shaft may at any time be subjected to, by the length of the crank or radius of the wheel in feet, &c.; divide their product by the *value* in the preceding tables, and the cube root of the quotient will give the diameter of the shaft or its journal in inches.

Example.—What should be the diameter for the journal of a wrought iron water-wheel shaft, the extreme pressure on the crank pin being 59,400 lbs. and the crank 5 feet in length?

$$\frac{59400 \times 5}{125} = 2376 \text{ and}$$

$$\sqrt[3]{2376} = 13{\cdot}34 \text{ ins.}$$

When two Shafts are used, as in Steam Vessels with one engine, &c.

Rule.—Divide three times the cube of the diameter for one shaft by four, and the cube root of the quotient will give the diameter of the shaft in inches.

Example.—The area of the journal of a shaft is 113 inches, what should be the diameter, two shafts being used?

Diameter for area of 113 = 12.

$$\text{Then } \frac{3 \times 12^3}{4} = 1296 \text{ and } \sqrt[3]{1296} = 10{\cdot}9 \textit{ ins.}$$

Note.—The examples here given are deduced from instances of successful practice; where the diameter has been less, fracture has almost universally taken place, the strain being increased beyond the ordinary limit.

2. When the work to be performed is of a regular character and the stress is consequently uniform, the proportion of $\frac{7}{8}$ths may be reduced to $\frac{5}{8}$ths.

Relative values of Cast and Wrought Iron.

When shafts of less diameter than 12 inches are required the *values* here given may be slightly reduced, according to the quality of the iron and the diameter of the shaft to be used; but when they exceed this diameter, the *values* may not be increased in a like manner, as the strength of a cast or a wrought iron shaft decreases as their diameters increase.

Grier makes the difference between cast and wrought iron shafts for all diameters as ·963 to 1·000.

To ascertain the Torsional Strength of Hollow Shafts and Cylinders.

Rule.—From the fourth power of the exterior diameter subtract the fourth power of the interior diameter and multiply the remainder by the *value* of the material; divide this product by the product of the ex-

terior diameter and the length or distance from the axis at which the stress is applied in feet: the quotient will give the resistance in pounds.

Example.—What torsional stress may be borne by a cast iron hollow shaft, having diameters of 3 and 2 inches, the power being applied at 1 foot from its axis?

$$3^4 - 2^4 \times 105 = 81 - 16 \times 105 = 6825,$$

$$\text{which} \quad \div 3 \times 1 = \frac{6825}{3} = 2275 \textit{ lbs.}$$

The order of journals of shafts, with reference to the degree of torsional strength to which they are subjected, is as follows:—

1. Fly-wheel shafts.
2. Water-wheel shafts.
3. Secondary shafts.
4. Tertiary shafts, &c., &c.

Hence, the diameters of their journals may be reduced in this order.

Relative Value of Different Materials to Resist Torsion. By English Authors.

Materials.		Value.	Materials.		Value.
Cast Iron,	1·00	112	Brass,	·28	31
Wrought Iron,	1·12	125	Copper,	·25	28
do Swedish	1·05	117	Tin,	·15	17
Cast Steel,	2·17	243	Lead,	·11	12
Shear do,	1·88	210	Oak,	2·24	250
Blistered do,	1·84	206	White Pine,	2·05	228
Gun Metal (bronze),	·33	37			

Relative Value of Different Figures to Resist Torsion, Having Equal Sectional Areas.

Solid Cylinder.	Solid Square.	Hollow Cylinders, the interior and exterior diameters of which are in the proportion of				
		4 to 10.	5 to 10.	6 to 10.	7 to 10.	8 to 10.
1·000	·8750	1·2656	1·4433	1·7000	2·0864	2·7377

—

Detrusive Strength.

The Detrusive strength of any body is directly as its depth or thickness.

Table of the Results of Experiments upon the Detrusive Strength of Metals.

Materials.	Diameter of shear or punch.	Thickness of metal.	Power exerted.	Power required for a surface of one square inch, viz:— 1 inch in depth, and 1 inch in width.
	Inch.	Inch.	lbs.	lbs.
Wrought Iron,	·5	·08	6,025	45,000
	·5	·17	11,950	
	·5	·24	17,100	
Copper,	·5	·08	3,983	30,000
	·5	·17	7,823	
Steel,	·5	·25	34,720	90,000
Fir,	·32	1·	600	600

Note.—The free use of oil reduces the power required very materially.

4*

Comparison between Detrusive and Transverse Strengths.

Assuming the compression and abrasion of the metal in the application of a punch of one inch in diameter to extend to one-eighth of an inch beyond the diameter of the punch, the comparative resistance of wrought iron to *detrusive* and *transverse* strain, the latter estimated at 600 lbs. per square inch, for a bar one foot in length, is as 2·5 to 1.

Character of Strains to which Connecting Rods, Straps, Gibs, and Keys are subjected.

Heads of Rods.—At sides of keyholes, tensile and compressive; at back of keyholes, detrusive.

Straps.—At crown and sides of keyhole, tensile; at back of keyholes, detrusive.

Gib.—Transverse, uniformly loaded along its length, fixed at both ends.

Key.—With single gib, transverse, uniformly loaded along its length, supported at both ends.

Key.—With double gib, transverse, uniformly loaded along its length, fixed at both ends.

WOODS.

When a Beam or any piece of wood is let in (not mortised) at an inclination to another piece, so that the thrust will bear in the direction of the fibres of the beam that is cut, the depth of the cut *at right angles to the fibres,* should not be more than one-fifth of the length of the piece, the fibres of which, by their cohesion, resist the thrust.

To ascertain the Force necessary to Punch Iron or Copper Plates.

RULE.—Multiply the product of the diameter of the punch and the thickness of the metal by 150,000 if for wrought iron, and by 96,000 if for copper, and the product will give the power required, in pounds.

(To be Continued.)

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By WM. BRYSON, Civ. Eng.

(Continued from page 396, vol. xli.)

Tables showing the calculated breaking weight and safe weight of uniform solid cylindrical pillars of cast iron, and the calculated weight of metal contained in each pillar.

Formula for the breaking weight of solid pillars of cast iron, their length or height exceeding 25 times their diameters, both ends of the pillars being flat and firmly fixed:—

$$W = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}.$$

The following formulæ, although not given by Mr. Hodgkinson, are applicable for the safe weight of solid pillars of cast iron, the length or height of the pillars exceeding 25 times their diameters.

For the safe weight, both ends of the pillars being flat and firmly fixed,

$$W = 11{\cdot}04 \frac{D^{3.55}}{L^{1.7}} .$$

For the safe weight, if irregularly fixed,

$$W = 4{\cdot}416 \frac{D^{3.55}}{L^{1.7}} .$$

NOTE.—The co-efficient 4·416 in this formula is, perhaps, rather too low.

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4} c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	30	2	49·13	33·52		8·38	3·35
6	36	"	58·95	24·58		6·14	2·45
7	42	"	68 78	18·91		4·72	1·89
8	48	"	78·61	15·07		3·76	1·50
9	54	"	70·43	12·34		3·08	1·23
10	60	"	98·26	10·31		2 57	1·03
11	66	"	108·08	8·77		2·19	0·87
12	72	"	117·91	7·56		1·89	0·75
13	78	"	127·74	6·60		1·65	0·66
14	84	"	137·56	5·82		1·45	0·58
15	90	"	147·39	5·17		1·29	0·51
16	96	"	157·22	4·64		1·16	0·46
17	102	"	167·04	4·18		1·04	0·41
18	108	"	176·87	3·79		0·94	0·37
19	114	"	186 69	3·46		0·86	0·34
20	120	"	196·52	3·17		0 79	0·31
5	24	2½	76·77		69·99	17·49	6·99
6	28·8	"	92·12	54·32		13·58	5·43
7	33·6	"	107·47	41·79		10·44	4·17
8	38·4	"	122·83	33·30		8·32	3·33
9	43·2	"	138·18	27·26		6·81	2·72
10	48	"	153·54	22·79		5·69	2·27
11	52·8	"	168·89	19·38		4·84	1·93
12	57·6	"	184·24	16·71		4·17	1·67
13	62·4	"	199·60	14·59		3 64	1·45
14	67·2	"	214·95	12·86		3·21	1·28
15	72	"	230·31	11·44		2·86	1·14
16	76·8	"	245·66	10·25		2·56	1·02
17	81·6	"	261·01	9·24		2 31	0·92
18	86·4	"	276·37	8·39		2·09	0·83
19	91·2	"	291·72	7·65		1·91	0·76
20	96	"	307·08	7·01		1·75	0·70

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16 \frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	20	3	110·55		122·08	30·52	12·20
6	24	"	132·66		98 83	24·70	9·88
7	28	"	154·77	79·81		19·95	7·98
8	32	"	176 88	63 60		15·90	6·36
9	36	"	198·99	52·06		13·01	5·20
10	40	"	221·11	43·52		10·88	4·35
11	44	"	243·22	37·01		9·25	3·70
12	48	"	265·33	31·92		7·98	3·19
13	52	"	287·44	27·86		6·96	2·78
14	56	"	309·55	24·56		6·14	2·45
15	60	"	331·66	21·84		5·46	2·18
16	64	"	353·77	19·57		4·89	1·95
17	68	"	375·88	17·65		4·41	1·76
18	72	"	397·99	16 02		4·00	1·60
19	76	"	420·10	14·61		3 65	1·46
20	80	"	442·22	13·39		3·34	1·33
5	17·142	3½	150·49		192·70	48·17	19·27
6	20·571	"	180·58		158 62	39·65	15·86
7	24	"	210·68		132·32	33·08	13·23
8	27·428	"	240·78	109 95		27·48	10·99
9	30·859	"	270·88	90·00		22·50	9·00
10	34·285	"	300·98	75·24		18·81	7·52
11	37·714	"	331·07	63·99		15·99	6·39
12	41·142	"	361·17	55·19		13·79	5·51
13	44·571	"	391·22	48·17		12·04	4·81
14	48	"	421·37	42·46		10 61	4·24
15	51·428	"	451·47	37·76		9·44	3·77
16	54 857	"	481·56	33·84		8·46	3·38
17	58 284	"	511·66	30·52		7·63	3·05
18	61·714	"	541·76	27·70		6 92	2·77
19	65·142	"	571·86	25·26		6·31	2·52
20	68 571	"	601·96	23·15		5·78	2·31
5	15	4	196·55		282·98	70·74	28·29
6	18	"	235·86		236·53	59·13	23·65
7	21	"	275·17		199·68	49·92	19·96
8	24	"	314·48		170·35	42·58	17·03
9	27	"	353·79	144·58		36·14	14·45
10	30	"	393·10	120·87		30·21	12·08
11	33	"	432·41	102·79		25·69	10·27
12	36	"	471·72	88·66		22·16	8 86
13	39	"	511·03	77·38		19·34	7·73
14	42	"	550·34	68·22		17·05	6·82
15	45	"	589·65	60·67		15·16	6·06
16	48	"	628 96	54·36		13·59	5·43
17	51	"	668·27	49·04		12·26	4·90
18	54	"	707·58	44·50		11·12	4·45
19	57	"	746·89	40·59		10·14	4·05
20	60	"	786·20	37·20		9 30	3·72

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16\frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b+\frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	13·333	4½	248·77		393·64	98·41	39·36
6	16	"	298·52		333·64	83·41	33·36
7	18·666	"	348·27		284·84	71·21	28·48
8	21·333	"	398·03		245·20	61·30	24·52
9	24	"	447·78		212·86	53·21	21·28
10	26·666	"	497·54	183·62		45·90	18·36
11	29·333	"	547·29	156·15		39·03	15·61
12	32	"	597·04	134·68		33·67	13·46
13	34·666	"	646·80	117·55		29·38	11·75
14	37·333	"	696·55	103·63		25·90	10·36
15	40	"	746·31	92·16		23·04	9·21
16	42·666	"	786·06	82·58		20·64	8·25
17	45·333	"	845·81	74·49		18·62	7·44
18	48	"	895·57	67·60		16·90	6·76
19	50·666	"	945·32	61·66		15·41	6·16
20	53·333	"	995·08	56·51		14·12	5·65
5	12	5	307·13		525·14	131·28	52·51
6	14·4	"	368·55		450·75	112·68	45·07
7	16·8	"	429·98		388·84	97·21	38·88
8	19·2	"	491·40		337·58	84·39	33·75
9	21·6	"	552·83		295·11	73·77	29·51
10	24	"	614·26		259·78	64·94	25·97
11	26·4	"	675·68	226·98		56·74	22·69
12	28·8	"	737·11	195·77		48·94	19·57
13	31·2	"	798·53	170·87		42·71	17·08
14	33·6	"	859·96	150·64		37·66	15·06
15	36	"	921·39	133·97		33·49	13·39
16	38·4	"	982·81	120·05		30·01	12·00
17	40·8	"	1044·24	108·29		27·07	10·82
18	43·2	"	1105·66	98·26		24·56	9·82
19	45·6	"	1167·09	89·63		22·40	8·96
20	48	"	1228·52	82·15		20·53	8·21
5	10	6	442·26		851·39	212·84	85·13
6	12	"	530·71		746·79	186·69	74·67
7	14	"	618·76		656·17	164·04	65·61
8	16	"	707·61		578·56	144·64	57·85
9	18	"	796·06		512·41	128·10	51·24
10	20	"	884·52		456·04	114·01	45·60
11	22	"	972·97		407·91	101·97	40·79
12	24	"	1061·42		366·66	91·66	36·66
13	26	"	1149·87	326·40		81·60	32·64
14	28	"	1238·32	287·76		71·94	28·77
15	30	"	1326·78	255·92		63·98	25·59
16	32	"	1415·23	229·32		57·33	22·93
17	34	"	1503·68	206·86		51·71	20·68
18	36	"	1592·13	187·71		46·92	18·77
19	38	"	1680·58	171·22		42·80	17·12
20	40	"	1769·04	156 93		39·23	15·69

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}34 \frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4}c}$.	Safe weight in tons.
8	12	8	6½	427·52		530 06	132·51
9	13½	"	"	480 96		490·19	122 54
10	15	"	"	534·40		453·32	113·33
11	16½	"	"	587·84		419·48	104·87
12	18	"	"	641 28		388·57	97·14
13	19½	"	"	694·72		360·32	90·08
14	21	"	"	748·17		334·81	83·70
15	22½	"	"	801·61		311·54	77·88
16	24	"	"	845·05		290·39	72·59
17	25½	"	"	908·49		271·16	67·79
18	27	"	"	961·93		253·67	63·41
19	28½	"	"	1015·37		237·71	59·42
20	30	"	"	1068 81		223·15	55·78
21	31½	"	"	1122 25		209·84	52·46
22	33	"	"	1175·69	194·04		48·51
23	34½	"	"	1229·13	179 92		44·98
24	36	"	"	1282·57	167·36		41·84
25	37½	"	"	1336 01	156·14		39 03
26	39	"	"	1389·45	146·07		36·51
27	40½	"	"	1442 89	136·99		34·24
28	42	"	"	1496·33	128·78		32·19
29	43½	"	"	1549·78	121·32		30·33
30	45	"	"	1603·22	114·52		28·63
8	10⅔	9	7½	486·49		645·89	161·47
9	12	"	"	547·30		602·84	150·71
10	13⅓	"	"	608·11		562·33	140·58
11	14⅔	"	"	668·92		524·52	131·13
12	16	"	"	729·74		489·45	122·36
13	17⅓	"	"	790·55		457·04	114·26
14	18⅔	"	"	851·36		427·20	106·80
15	20	"	"	912·17		399·76	99·94
16	21⅓	"	"	972·98		374·54	93·63
17	22⅔	"	"	1033·80		351·38	87·84
18	24	"	"	1094·61		330·13	82·53
19	25⅓	"	"	1155·42		310·58	77·64
20	26⅔	"	"	1216·23		292·61	73·15
21	28	"	"	1277·04		276·07	69·01
22	29⅓	"	"	1337·85		260·82	65·20
23	30⅔	"	"	1398·67		246·76	61·44
24	32	"	"	1459·48	232·32		58·08
25	33⅓	"	"	1520·29	216·75		54·18
26	34⅔	"	"	1581·10	202·76		50·69
27	36	"	"	1641·91	190·17		47·54
28	37⅓	"	"	1702·73	179·46		44·86
29	38⅔	"	"	1763·54	168·41		42·10
30	40	"	"	1824·35	158·97		39 74

(To be Continued.)

Chronograph with Conical Pendulum. By M. MARTIN DE BRETTES. Constructed by M. HARDY; described by M. DESPRETZ.

This chronograph consists of a metallic cylinder covered by a band of paper. A platinum point is revolved around this cylinder by clock-work, the motion being regulated by a conical pendulum. It makes a turn in one second, and the spaces described are proportional to the times. Very small fractions of a second may be measured on this instrument, since the space described in a second is 75 centimetres (29½ inches). The point does not touch the paper, but an electric spark pierces the paper at each rupture of the circuit.

In using this apparatus in balistic experiments, a wire screen through which the ball passes is put into connexion with the inducing circuit, and placed at any desired point of the trajectory.

M. Despretz reminds us that many learned men have invented chronographs and chronoscopes, and he mentions a number of English, French, and Russians. It may not be improper to add to his list the names of Bond of Cambridge, Locke of Cincinnati, Sears Walker of Washington, who first applied the electric current to the registering of astronomical observations, and Prof. Henry of the Smithsonian Institution, who proposed the first application of it to balistic experiments.

Sulphur in Coal Gas.

From the London Engineer, No. 274.

Some attention has lately been directed to the fact of the existence of compounds of sulphur in coal gas used for illuminating purposes. In an interesting report upon the subject, by F. Versmann, F. C. S., it is pointed out by this chemist that, however desirable it may be to perfect the means for purifying gas, there is no occasion for any degree of alarm on the part of the public with regard to the amount in which the impurities in question exist, or their effect upon health. The means for determining the proposition of sulphur in gas are simple, and susceptible of great accuracy. The gas is burnt in atmospheric air contained in a close glass vessel, and in contact with a solution of ammonia. The products of combustion are further made to pass through two Woolf's bottles; the first containing a solution of ammonia, the second a solution of iodine in iodide of potassium. The latter solution was employed by Mr. Versmann in case some of the sulphurous acid resulting from the combustion should escape absorption by the ammonia; but it was found that not a trace of sulphur could be detected in the second bottle. The sulphurous acid, combined with ammonia, as sulphite of ammonia is converted into sulphuric acid by a solution of iodine in iodide of potassium, precipitated by chloride of barium, and weighed as sulphate of barytes.

The following table represents the results of the experiments according to this process:

FIRST SERIES OF EXPERIMENTS, MADE AT THE WORKS OF THE COMMERCIAL GAS COMPANY.

Commencement of the experiment.	Duration of experiment in hours.	Cubic feet of gas burnt.	Grains of $Ba\,O.SO_3$ obtained.	Corresponding grains of sulphur.	Grains of sulphur calculated for 100 cubic feet of gas.	Mean of grains of sulphur calculated for 100 cubic feet of gas.
February 27, .	.23	13	3·08	0·42	3·23	2·99
do 28, .	95	30	6·80	0·94	3·12	
March 5, . .	217	75	14·41	1·98	2·64	
do 14, . .	294	118	25·42	3·49	2·96	
May 17, . .	6	3·5	1·53	0·21	6·00	6·35
do 21, . .	4·5	2	0·98	0·134	6·70	
SECOND SERIES OF EXPERIMENTS, MADE AT THE LABORATORY OF F. VERSMANN, WITH GAS OF THE CHARTERED GAS COMPANY.						
March 27, .	4	5	3·50	0·48	9·60	9·41
do 28, .	9	14	10·60	1·46	10·43	
do 30, .	40	69	42·24	5·80	8·40	
April 4, . .	6	9	6·04	0·83	9·22	

In the experiments of Professor Hofmann, as detailed in a report to the Lords of the Committee of Privy Council on Education, the maximum amount of sulphur found in 100 cubic feet of gas is 10·33 grains. The variation in these results is in some measure explained by the fact that the formation of bisulphide of carbon greatly depends upon the following conditions:—1st, The dampness of the coals; because in very damp coals all sulphur will most probably be converted into sulphuretted hydrogen. 2d, The degree of heat to which the coals are exposed; and, 3d, Upon the quantity of sulphur present in the coals.

It is shown, however, by Mr. Versmann, that even the largest quantity of sulphur found in coal gas is comparatively so small that the difference becomes insignificant. Thus, according to the results obtained, 10,000 parts by weight of gas contain in three different samples, 1·2, 2·6, and 3·8 parts of sulphur respectively; or, if we compare the volume of the coal gas to those of the bisulphate of carbon, 10,000 parts by volume contain 0·236, 0·480, and 0·747 cubic feet respectively of vapors of bisulphide of carbon.

When the amount of carbonic acid gas produced by the combustion of coal gas is compared with that of the sulphurous acid gas resulting from the sulphur compounds, it becomes evident that the contam-

ination of the atmosphere of an apartment by the former agency must necessarily reach a very high point before any inconvenience or injury can be occasioned by the sulphurous acid. To whatever extent ventilation is employed, the deterioration of the air to a serious degree is to be apprehended long before the acid gas can exert any sensible action. With every 50,000 cubic feet of carbonic acid, 4·7, 10·12, or 14·8 cubic feet of sulphurous acid only would be formed from the gas of which samples were analyzed by Mr. Versmann. In this proportion, it could have no injurious effect upon the human constitution while ventilation was sufficiently active to remove the enormous proportionate volume of carbonic acid. The same quantity of sulphur would be burnt by lighting three, seven, or ten of the ordinary lucifer matches, as in the consumption of 100 cubic feet of gas containing 2·99, 6·35, or 9·41 grains of sulphur. These considerations may have the effect of removing any apprehensions of injury resulting from the presence of sulphur in gas, which may have been occasioned by the discussion on this subject.

Translated for the Journal of the Franklin Institute.

Artificial Madder.

M. Dumas announced to the Academy of Sciences of Paris, that M. Roussin had obtained *alizarine*, the coloring principle of madder, from naphthaline.

A mixture of bi-nitro-naphthaline with concentrated and pure sulphuric acid, is placed in a large porcelain capsule heated by an oil or sand-bath By raising the temperature, the bi-nitro-naphthaline dissolves completely in the sulphuric acid. When the mixture has reached 392° Fahr. granulated zinc is dropped into the mixture gradually, and with careful observation not to allow the temperature to rise much. In a few minutes a disengagement of sulphurous acid takes place, and the operation is terminated in about half an hour. If a drop of the acid liquid is then allowed to fall into cold water, a magnificent violet color is developed, due to *alizarine.*

When the reaction is over, the liquid is diluted with 8 or 10 times its volume of water and brought to the boiling-point, and after boiling a few minutes, thrown into a filter. The alizarine is deposited upon cooling as a red jelly, sometimes adhering to the vessels, sometimes suspended in the liquid. Examined by the microscope it is seen to be composed of needle-shaped crystals of great definiteness. The mother-waters are strongly red from dissolved alizarine, and may be used to dye directly. A quantity of alizarine remains in the filter, which may be removed by caustic alkalies.

In the preceding reaction the zinc may be replaced by any one of a number of substances, such as iron, mercury, sulphur, carbon, or in short, by any substance which reacts at a high temperature with sulphuric acid, with the production of sulphurous acid.

The substance thus obtained possesses all the characters and re-

actions of alizarine. It is but slightly soluble in water, but soluble in alcohol and ether. Volatilizes between 419° and 464° Fahr. with a yellow vapor, and gives deep red needle-shaped crystals, whose tone of color is very variable. It is not attacked by chlorhydric or concentrated sulphuric acid. It dissolves in caustic and carbonated alkalies with a deep blue purple color. Acids precipitate this solution in deep orange-red flocculi. Like alizarine from madder, it furnishes lakes of the most beautiful colors. It is fixed on stuffs like natural alizarine, and gives similar tints.

Nothing remains but to determine the composition of these two substances comparatively; until that is done their identity cannot be definitely affirmed.—*Cosmos.*

On the Welding of Malleable Iron. By JAMES NASMYTH, Esq., C. E.

From the Lond. Engineer, No. 271.

Of all the processes connected with the working of malleable iron, there is none that has a more intimate relation to the security of life and property than that of "welding," or the process by which we are enabled to unite together, in one mass, the several portions of malleable iron, of which the generality of works in that material are formed.

Every single link in a chain-cable, every wheel tyre in a railway train, directly owes its trustworthiness to the manner in which the process of welding has been performed, in so far as that any imperfection in one single member of the set of cable links or railway wheel tyres may involve a most fearful loss of life, of which, of late years especially, we have had such distressing and melancholy experience.

It is with the most earnest conviction of the vital importance of the process of welding, by reason of its close relation to the security of life and property, that I am anxious to offer a few remarks, based on long and intimate acquaintance with the process in question, and on those conditions that conduce to its perfect performance, which remarks I am fain to think, if read with due care and consideration by those who are more specially concerned with the practice of the process of welding iron, may in no small degree tend to render less frequent those fearful and distressing catastrophes of which recent records of ship and railway disasters furnish such sad evidence.

In order to render more clear the following remarks as to the cause, and most certain means of the prevention of defective welding, it may be as well, at the risk of a little tediousness, to explain the nature of the process of welding iron, which consists in inducing upon malleable iron, by means of a very high heat, a certain degree of adhesiveness, so that any two pieces of malleable iron, when heated to the requisite degree, will, if brought into close contact, adhere or stick together with a greater or less tenacity, according to the amount of force applied to urge them into close contact.

But as malleable iron, when heated to the high temperature requisite to induce the adhesive or weldable condition, is at the same time rendered highly oxidizable, the surface of the iron at the welding hot part becomes enveloped with a coat of vitrified oxide, which adheres

to the metal with great obstinacy; and although this molten oxide can be rendered more fluid, and the further oxidation in some degree restricted, by sprinkling the welding hot surface of the iron with sand, which, combining with the molten oxide, renders it more fluid, and, therefore, more easily removable from the surface of the iron, yet so rapid is the oxidation of the iron when at the high heat requisite for welding, that unless the utmost care be taken and some special means applied for the purpose, more or less of this vitrified oxide is certain to be shut up between the surfaces at the welded part, and a defective junction is the consequence, which defect (as is but too frequently the case), giving no external evidence of its existence, may develop itself in the most unexpected manner, and result in a fearful catastrophe.

It is, therefore, to the means of thoroughly expelling this vitrified oxide from between the surfaces of the iron where the welded junction is to take place that we must direct our attention, for so long as any portion of this adhesive viscid substance is permitted to exist and interpose itself between the surfaces we desire to unite by welding, no sound or trustworthy junction can take place, and once it has made a lodgment no after-heating or hammering, be it ever so severe, will cause its thorough expulsion. It is, therefore, to the thorough expulsion of the vitreous oxide in the first stage of the welding that we must direct the most careful attention, and it would, in no small degree, tend to bring to an end those fearful accidents of which defectively-welded iron-work is so fertile a cause, if all those who are specially and practically concerned with the superintendence of workmen entrusted with the performance of this vitally important process, would see to the use and practice of the truly simple means which I am about to describe.

Fortunately the means of securing a perfectly sound and trustworthy welding are as simple as they are effective, and if those who are entrusted with the superintendence of this vitally important process and of the workmen who perform it, would but give their earnest personal attention to see that the simple and common-sense mode of operation which I am about to describe were in every case attended to, we should bring to an end a fertile source of mischief and disaster.

As I have before said, the chief cause of defective welding arises from portions of the vitreous oxide of the iron being shut up between the surfaces at the part presumed to have been welded, and that besides the impossibility of ascertaining, in the majority of cases after the process of welding has been gone through, whether or not this vitreous oxide has been thoroughly expelled, and the surfaces at the welding brought into perfect metallic union, and that no after-heating or hammering can dislodge the vitreous oxide when once it has effected a lodgment.

Our best and only true security is to form the surfaces of the iron at the part where the welding is desired to take place, so that when applied to each other, when at the welding heat, *their first contact with each other shall be in the centre of each.* Fig. 1 will represent two such surfaces formed in such a manner as to come into contact with each

other in the centre of each, so that when they are urged into close contact by the aid of the hammers, a free escape and means of egress for the interposed matter, vitreous oxide, may be preserved to the last, as indicated in the figures given.

I think it will not require tedious or elaborate description from me to impress on the attention of all who are specially interested in this subject, the practical value of this common-sense and truly valuable, as well as simple, means of effecting the thorough expulsion of the vitreous oxide, as the mode I have pointed out is not only in the highest degree simple and effective, but is also capable of application in every case in which this vitally important process of welding is requisite in the formation of works in malleable iron.

Fig. 1.

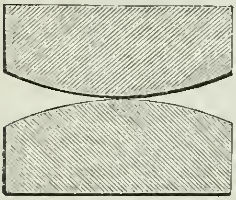


Fig. 3.

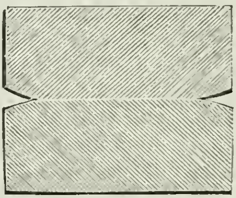


Fig. 5.

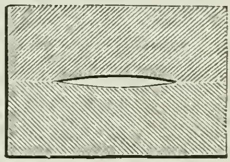


Fig. 2.

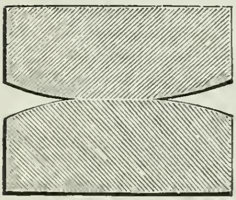


Fig. 4.

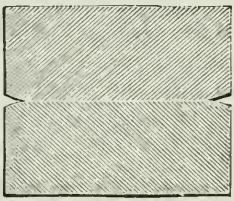
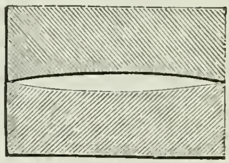


Fig. 6.



In order still further to impress on the attention the distinctive characters and value of this simple means of getting quit of the most fertile cause and source of defective welding and its but too frequent fatal consequences, I may as well give a figure of the form of the surfaces of iron-work, as frequently prepared for welding by workmen who are not intelligently alive to the importance of thoroughly dislodging the vitreous oxide from between the surfaces of the parts desired to be welded. Such ignorant or negligent formation of the surfaces is but too frequently made of the nature as indicated in Fig. 5, namely, they are allowed to assume a concave in place of a convex form, and the consequence of such is, that when these surfaces are brought together at a welding heat, and their cohesion aided by the action of the hammers, after the first splash of vitreous oxide is drawn forth by the few first blows of the hammers, the residue remains behind so effectually shut up that no after heating or hammering will ever expel it, and the work resulting will be, in consequence, charged with mischief and fatal disaster, and that all the more dangerously so inasmuch as that the welding of such *concave* surfaces will, from having taken place at the outside part, present all the outward aspect of perfect soundness, as seen in Fig. 6.

Unfortunately, it does happen sometimes that, owing to the simplicity and obviousness of certain improvements in the processes connected with practical matters of the class in question, they do not receive that degree of notice and earnest attention that is given to more elaborate, complex, and "scientific-looking" so-called improvements.

I trust, however, that a consideration of the intimate connexion which the process of welding has with the security of life and property will obtain, for the common-sense means which I have detailed for averting those sad catastrophes which but too often are the direct result of the defective welding of iron, that degree of careful and earnest attention which, I doubt not, every intelligent practical man will give to them.

The Adriatic.

From Mitchell's Steam-Shipping Journal, No. 85.

The steamship *Adriatic*, Captain Jefferson Maury, which arrived here on Sunday morning from New York, and is now the property of the Atlantic Royal Mail Company, was taken to Stokes Bay to-day for an official trial trip before entering on the mail service under the British flag. She made four runs on the measured mile with the following results:—First run, 4 min. 31 sec., equal to 13·284 knots per hour; second, 3 min. 18 sec., or 18·181 knots; third, 4 min. 20 sec., or 13·846 knots; fourth, 3 min. 21 sec., or 17·910 knots; giving a mean speed of 15·908 knots per hour. Revolutions of engines during trial, 17 to 18; pressure of steam, 25 lbs.; vacuum, 25 lbs., with surface condensers. Draft of water, forward, 17 feet 2 ins.; aft, 18 feet 10 ins.; 113 tons of coal on board. The usual authorities of the Admiralty and the Board of Trade were present to witness the trial, together with some of the Company's officials, and a few other scientific gentlemen. The *Adriatic* goes into dry dock to be surveyed, and will leave for Galway in the course of a few days. This fine steamship has excited much attention among nautical men during the time she has been lying in our docks, her beautiful lines, as well as the extent and splendor of her internal arrangements, being much admired by all who have paid her a visit.

SOUTHAMPTON, March 27.

Photo-Sculpture.

M. François Willème proposes the following very ingenious application of the photograph to sculpture:

The model is placed in the centre of a circular platform, around which are arranged at equal heights a number of similar cameras: or around which, one camera can be moved so as to be placed in successive positions at the same distance from the model: in this way a considerable number of photographs are taken. Let us, for the sake of illustration, suppose four: the first, A, presenting the face view; B, the profile from the right; C, the back view; D, the profile from the

left. The material to be carved, which for the sake of simplicity we will suppose soft, is mounted on a circular platform whose circumference is symmetrically divided into as many parts as there are photographs. These photographs are mounted in frames adjusted in the same relative positions in which they were taken. A pantograph is then applied to the photograph A, and while one extremity traces the outlines, the other, provided with properly adjusted cutters, cuts out the face view from the block. The pantograph is then moved to the photograph B, and the right profile cut; and so on for the others. Of course four photographs would not be sufficient, but any even number may be taken, say twenty-four, and they are cut in such order as to cause each photograph to be succeeded by the one at right angles to it: thus, in the case of twenty-four photographs, the order will be 1, 7, 2, 8, 3, 9, &c. When these cuttings are finished, but little is left for the hand in rounding off the angles and finishing the contours, and an accurate representation of the original will have been furnished in an entirely mechanical way.—*Cosmos.*

Lime as a Protection for the Vine.

A correspondent of the *Cosmos* writes that he has succeeded in protecting his vines perfectly against the *öidium* by simply white-washing the plant and especially the new wood, wherever it appeared affected. He says that he has pursued this course for three years and with entire success.

Perhaps the experiment might be worth trying here in reference to other nuisances.—*Cosmos.*

Apparatus for Testing Silk.

From the Lond. Mechanics' Magazine, Dec., 1860.

This is an apparatus newly invented by M. Froment, for testing the tenacity and elasticity of silks of different sorts. The dynamometric portion of the apparatus is composed of a small, thin, and very flexible lamina of steel horizontally fixed in its centre. Its extremities are connected by two small rods to a single shaft rising to some height, and having its upper extremity finely split for the purpose of fixing the thread to be tested. When this thread is subjected to traction, it causes the lamina or spring above described to bend, and this motion is communicated to the hand of a dial-plate. When the thread snaps, this hand remains at the point to which it had been brought by the effect of the traction. The other portion of the apparatus by which the traction is effected, is a piece of clock-work which descends by its own weight. It is provided with a pair of pincers, into which the other end of the thread is inserted. By means of this apparatus, M. Persoz has been enabled to make experiments on the tenacity of various silks, the results of which he has communicated to the *Société Impériale d'Acclimatation.* Thus, the threads tested being all of the length of half a metre, M. Persoz shows that the tenacity of the Cal-

cutta cocoon is represented by 5·3, that of Teneriffe 5·2, while those from Avignon and Prussia were 12 and 12·9 respectively; that of Neuilly marked 8. The elasticity of these sorts per metre were respectively 9·9, 12·8, 14·4, 13·4, and 12·9. The following general conclusions derived from these experiments are interesting:—1. The male cocoon yields a finer and more tenaceous silk than the female one. 2. The same species reared on different soil and in different climates does not yield threads of the same tenacity. The latter fact, M. Persoz thinks, should induce the *Société d'Acclimatation* to undertake experiments for the sake of determining with precision the effects which soil and climate, as well as the kind of food, produce on the silk-worm.—*Galignani's Messenger.*

Velocity of Light.

M. Leon Foucault has finished an improvement on his rotating mirror, and is preparing to measure accurately by it the velocity of light. He hopes thus to determine the real distance of the Sun from the Earth, and to furnish M. Leverrier with a datum of which he has great need, in his theories of the Sun, Mercury, Venus, and Mars.—*Cosmos.*

On Plastic Wood. By Mr. Francis Steinitz.

From the Journal of the Society of Arts, Nos. 424, 425.

Sir—Observing in the last number of your Society's *Journal*, a short article on the above subject, extracted from a communication to the *Times* by its Paris correspondent, I venture to offer a few observations, which may prevent erroneous views from being taken in connexion with this invention.

I endeavored, about ten years ago, to produce ornamental plastic wood, by the application of pressure and softening the woods, and succeeded to a certain extent, by cold pressure, but without softening the wood; but, as I had anticipated, the "relief" was of very slight depth. Several kinds of wood are capable of being softened by boiling or steaming, (the process adopted for knife-cutting veneers and bending sticks, shafts, and other carriage and ship-building work,) but very few indeed can be sufficiently softened to replace the carving for furniture making. Those foreign woods which are figured by fibres, or various excrescences, or which have fibres traversing the annual rings, are by no means adapted for that purpose. Equally unsuitable are dark-colored woods, in which, even when the impression is successful, the outline of the "relief" is much less distinct than in light-colored ones. Of the latter, lime-tree, poplar, and willow might be used effectually so far as regards the sunk parts of the ornaments, which could easily be pressed into the softened wood, but it is very improbable that the raised parts, retaining the original soft nature of the wood, would ever become sufficiently hardened to resist the effects of time. To apply a chemical remedy would not only be costly, but also detrimental to the texture

and color of many woods, especially oak; the mere application of water or steam to oak will change the color from an agreeable pale-yellow to an unpleasant reddish hue.

Walnut is, indeed, susceptible of being easily softened; but although it is much liked in England for some descriptions of furniture, when it is richly figured, the plainer sorts would, on account of their dull color, probably meet with little favor for the imitation of carving.

Several East Indian, Chinese, and Brazilian woods might be named which, being soft as sponge, and yet fine-grained, are especially suitable for pressure, but they are all open, and even to a greater degree, to the objection which I have suggested against the use of the English light-colored woods. Such delicate carvings as are executed with the chisel by Mr. Rogers and other sculptors, can certainly not be produced by pressure; while if, as we may presume from the list of articles named by the inventor, only a shallow description of carving is aimed at, this can be executed with great nicety by the turning lathe on the "guilloche" system, frequently used for portraits in ivory and wood, and now very much applied to straw-colored coach-panels, imitating basket-work. But if the imitation of carving of a more raised character be wished for, I believe there is nothing so well adapted as leather ornaments, which have now been brought to an excellent state, and are not very expensive.

As everything connected with wood is in the highest degree interesting to me, I am anxious to obtain as much information as possible on any new invention relating to it; and hope these lines may give occasion to a closer investigation of the subject, which would be much facilitated if the inventor would forward a few specimens to your next Exhibition. The few which accompany this letter are the results of experiments made ten years ago, and were only intended for book-sides, but found no favor for that purpose.

London Parquetry Company, Camberwell.

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The following additional information on this subject appears in the *Manchester Examiner*:—

One of the results of the late French treaty has been the introduction into this city of a new product of art and industry, called "bois duré," which will cause quite a revolution in the manufacture of many articles of ornament and general use, and, to judge by the remarkable applications that we have seen, the discovery is a great success. Bois duré, or hardened wood, which has been improperly described as wood softened and then hardened, is made from saw-dust, which, under the influence of a high temperature and the enormous pressure of 600 tons, acquires a hardness a good deal exceeding that of wood. It is of a very fine grain, and fears no atmospherical variation; but its principal merit is its adaptation to moulding, and by the most economical processes forms and impressions are given which would require, in any other way, considerable labor and workmanship. We have seen various articles of great beauty manufactured from it, such as writing-desks, inkstands, seal-handles, medallions of royal and public charac-

ters, and even binding for books; on these, carving and the most delicate sculpture are reproduced with the perfection of models, and with exquisite fineness of execution. In Manchester there are one or two places where the products of this new art can be seen.

Translated for the Journal of the Franklin Institute.

Diathermancy of Gases. By M. Magnus.

M. Magnus read to the Academy at Berlin the second part of his researches on the Diathermancy of Gases. After having in his first memoir established the conductivity of gases in general and especially that of hydrogen, he now examines their power of diathermancy.

The following are, in few words, the results to which he has come:

All gases stop a portion of the calorific rays which traverse them; and absorb more in proportion as they are more dense.

The atmospheric air and the gases which compose it, are those which suffer the most heat to pass through them.

Rays coming from different sources undergo different modifications; those from boiling water present the greatest differences in traversing different gases.

Among the colorless gases, ammonia allows the least heat to pass; after ammonia, olefiant gas.

The use of a tube increases the effects of calorific radiation, as it does those of luminous rays. The nature of the wall of the tube exerts a sensible influence upon the proportion of rays transmitted and absorbed; it follows that reflexion from the surface, modifies the composition of the beam which is traversing the gas.

This latter result might have been anticipated, after the experiments of M. Knoblauch.—*Cosmos.*

On the Preservation of Stone.

From the Civ. Eng. and Arch. Jour., March, 1861.

A series of special meetings has been held at the Royal Institute of British Architects, at the instance of Mr. Tite, M.P., for the discussion of the various processes for the preservation of stone from decay. Mr. Tite opened the discussion, and Mr. Digby Wyatt, the Vice-President, on the three evenings devoted to this subject, occupied the chair.

Mr. Tite gave a very detailed account of the various processes, and expressed his own opinion of the non-success of the applications in each case. Both in opening and closing the discussion, he denounced the processes of M. Szerelmey and Mr. Daines.

Mr. Burnell, after speaking warmly in disfavor of M. Szerelmey's Zopissa—which he said he had gathered in exfoliated scales that had fallen from the walls operated upon, and, in older specimens, had brushed off in clouds with his hand—stated that he knew of no process to which he could pin his faith or reputation.

The Hon. W. Cowper, M.P., said that, having the custody of the

Houses of Parliament, as First Commissioner of Works, he was most anxious to avail himself of the united experience of this Institute. That when he came into office, Sir C. Barry had recommended the process of M. Szerelmey, but that, on extended trial, it was found not advisable to proceed with its further adoption.

Mr. George Gilbert Scott stated that he had tried all the various processes upon the Abbey at Westminster, but all had proved failures in a greater or less degree. He good-humoredly chided M. Szerelmey for falsifying the character of his process, and finally stated that no system had yet gained his confidence.

Mr. Warrington—who stated, in reply to the chairman, that he was engaged professionally for Mr. Ransome—said a few words in support of the process on which he had been employed.

Mr. C. H. Smith, one of the commission appointed to select the stone for the Houses of Parliament, entered rather fully into the circumstances under which he became attached to that commission, and the steps that were taken for the selection of the stone; further remarking upon the negligence of the authorities in not appointing an overlooker properly to inspect the stone as it left the quarries. Certain changes had taken place in the spots from which the stone was obtained, which at last varied to the distance of six miles from the locality originally fixed upon. He had himself been offered the post of supervisor, but had not been able to discover a responsible paymaster. Had this been done, the stones so notoriously bad would not have been used in the building.

Prof. Ansted, in support of his colleague Mr. Ransome, said all that could be said in extenuation of the failures of his process, for the most part attributing them to unfavorable circumstances during the manipulation; but also venturing to suggest that some stones could not be preserved from decay, when decay once set in, by any process whatever. He acknowledged the state of things to be very unsatisfactory, and suggested that the matter be referred to a committee of scientific men for a more thorough investigation.

Mr. Godwin gave some facts in the shape of negative evidence. He had witnessed the failure of Mr. Daines' process of sulphur and oil on a statue in front of the Foundling Hospital, which, after many attempts to preserve it, had fallen into such a state of decay that it had to be placed in the hands of the painters. He had the testimony of Mr. Calder Marshall to the complete failure of the process. He inveighed against the disfiguring of the Houses of Parliament by the inventors of so-called preserving processes, some few of whom had raised an agitation to suit their own purposes, and had gone far towards irremediably spoiling the characteristics of that superb building.

Mr. Ferrey spoke in favor of soft soap and alum, as being so cheap that its price would compensate for its frequently required application.

Mr. E. Barry exonerated his late father from imputed blame in the employment of Szerelmey's Zopissa on the New Palace; stating that qualified authorities had preferred this process to Mr. Ransome's, whose process he considered a failure, but the specimens of which he

had now labeled on the building, so that any one might have an opportunity of inspecting the result for themselves.

Prof. Hofmann stated his opinion on the process of M. Fuchs; but confessed that, beautiful as was the theory of the system, it was not suited to the humid atmosphere of England. He stated his objection to Mr. Ransome's process, which even as a theory he had pronounced a failure, as silicate of lime formed by precipitation of silica by calcium had no chemical affinity whatever with the constituents of the stone, and formed no union with it. He concluded by suggesting that the silicic ether, of which he had given a clear description, might be experimented upon to advantage.

Dr. Frankland, who in accordance with a previous request of Mr. Godwin stated that he was professionally employed by Mr. Ransome, spoke of the silicate of lime process; and ended by saying that, as the price of silicic ether was six guineas per lb., it could hardly be used for the purpose required.

Prof. Tennant coincided with the opinions of Prof. Hofmann on the subject principally under consideration.

After some further remarks from other speakers, the motion proposed by Mr. Godwin and seconded by Mr. Tite was carried unanimously—that the First Commissioner be requested to stay further proceedings at the New Palace at Westminster, and to form a committee of inquiry into the present state of decay of the building, and the best mode of arresting its further progress.—*Proc. Inst. of Brit. Arch.*

Gun-Cotton as a Filter. By Prof. Böttger.

Gun-cotton, being produced by the action of very powerful acids, and being, according to the experiments of the author, scarcely attacked by even the most energetic re-agents at ordinary temperatures, provided it have been well prepared, may be very advantageously used for filtering very acid liquids, and those easily affected, and in many cases is preferable to the substances heretofore used.

M. Böttger has used this means of separating chloride of silver from strong nitric acid; selenium from fuming sulphuric acid; crystals of chromic acid from sulphuric acid; and for the filtration of strong alkalies.—*Böttger's Polytechnisches Notizblatt* and *Dingler's Polytechnisches Journal;* quoted by *Bulletin de la Soc. d'Encouragement pour l'Industrie Nationale.*

Paper from Maize.

The French have discovered that paper can be made from Indian corn; and what is more curious, the *Cosmos* admits that the discovery is not entirely new. This is probably owing to its not being claimed by a Frenchman; otherwise, it is at least as new as blasting by galvanism, copying by telegraph, &c., &c., of which so much boasting is made.

But to the facts: M. Moritz Diamant, an Austrian, has invented a

process of making paper from Indian corn, which is now in use by M. le Comte Lippe-Weissanfeld.

All kinds of paper may be made from it, and in some respects the papers are superior to those made from rags. It requires but little sizing to fit it to receive ink, the natural leaf containing a substance which answers for it, but which can easily be extracted when desirable. It is bleached rapidly, easily, and inexpensively, and may be used for wrapping-papers without bleaching, as it is but slightly colored. It is stronger than the best paper from rags and has not the brittleness of straw-paper.

In M. Moritz's process, as no machine is necessary to convert the fibre into pulp, and this conversion is done in an entirely different way from the manufacture of paper from rags, there results a great simplification in the tools and a consequent notable reduction in the cost of making. A manufactory is now in operation in Switzerland. It is worthy of remark that the richest leaves in textile material are those which envelope the ear.—*Cosmos.*

On the Difference in Size of Medals of Different Metals obtained by Stamping, and by Casting in the Same Mould. By H. W. Dove.

From the Lond. Edin. and Dub. Phil. Mag., October, 1860.

Baudrimont has found (*Ann. de Chim. et de Phys.* vol. lx. p. 78) that wires of different metals drawn through the same press are not all of the same thickness; for they are of different degrees of elasticity, and after being drawn through the press they expand to different amounts. This expansion is proved by the fact that, with the exception of gold wire, no wire can be drawn through the same aperture through which it has been pressed. Silver requires the least force, but the expansion caused by elasticity continues for several weeks.

It appeared probable that in stamping medals something similar would prevail, and that medals of different metals stamped in the same die would be different in size. This is most readily seen in those medals in which the impression is symmetrically arranged in reference to the edge, as is the case with the medals of the French Exhibition, in which the coats of arms encircle the French eagle in the middle. One of those in silver, and one in bronze, were placed in the stereoscope, the eagle being fixed in the middle. After some time, the stereoscopic combined medal was seen in the form of a hollow escutcheon, and of the color of an alloy of the two metals. Evidently, the reason of this lies in the nonius-like shifting of the individual lines of the impression. This result, which I have described (*Optische Studien*, p. 29), I have also obtained with large gold and silver medals which were kindly entrusted to me from the Royal Mint in Berlin. It was probable that medals obtained by casting would show the same thing, and this was found to be the case with tin, bismuth, and lead. The casts were very beautifully executed for me for this purpose by Prof. Kiss. Hiero's crown led to the application of specific gravity to detect an adulteration; the stereoscope is a new means.—Poggendorff's *Annalen*, vol. cx. p. 498.

Painting by Centrifugal Force.

In the establishment of M. Deffner, at Esslingen, among other objects, they make large quantities of bird-cages. In order to paint the wires, they are first immersed in a vessel of the paint, suffered to drip for a few minutes, and then placed in boxes on the circumference of a horizontal wheel of about two feet diameter which is turned with great rapidity. By the centrifugal force thus generated, the excess of paint is thrown off, and a thin and even coating only is left.—*Mittheilungen des Hanoverschen Gewerbevereins; Bull. de la Soc. d'Encour. pour l'Ind. Nat.*

Sulphide of Phosphorus for Matches.

M. Puscher, of Nuremburg, proposes the use of sulphide of phosphorus in place of the phosphorus itself, in the manufacture of matches. It is easily made by taking 4 parts by weight of phosphorus and 1 of sulphur coarsely powdered, placing them in a vessel of porcelain and covering them with water at 100° Fah.; in a few minutes the liquid sulphide is formed. The water is poured off as far as possible and a cold, and very thick solution of gum is added. The sulphuret mixes with this solution with great ease and rapidity. The sulphide of phosphorus is fluid even at 32°, and inflames more easily by friction in the air than phosphorus itself. Excellent matches may be made by using only $3\frac{1}{2}$ per cent. of the sulphide. When the sulphide and gum are thoroughly powdered, the other ingredients, such as peroxide of lead, nitrate of lead, and a little sulphide of antimony are added. As the mixture is made cold, some rosin may be added to augment the flame. There is thus a great economy, both of phosphorus and of time, and the matches thus prepared have less smell than those made with phosphorus alone.—*Dingler's Polytechnisches Journal; Bull. de la Soc. d'Encour. pour l'Ind. Nat.*

AMERICAN PATENTS.

AMERICAN PATENTS ISSUED FROM APRIL 1, TO APRIL 31, 1861.

Adhesive Material, .	A. J. Russell, .	City of	N. Y.	2
Air Engines,—Hot	Stephen Wilcox, Jr.,	Westerly,	R. I.	2
———,—Steam and Hot	Darius Musselman, .	Lucas co.,	Ohio,	30
Amalgamator, .	S. E. Woodworth,	Murphy's,	Cal.	9
Augers,—Hollow .	S. P. Gilbert, .	Racine,	Wis.	2
Axes,—Manufacture of	Levi Dodge, .	Cohoes,	N. Y.	2
Axgave Americana,—Dressing	E. J. y Patrullo, .	Merida,	Mexico,	23
Baby Jumper, .	J. A. DeBrame, .	City of	N. Y.	30
Barometer, .	H. A. Clum, .	Auburn,	"	16
Bathing Apparatus,	J. C. Schooley, .	Cincinnati,	Ohio,	2
Bed,—Portable Folding .	G. N. Seidler, .	Hartford,	Conn.	2
——,—Spring .	Stewart Elder, .	Buffalo,	N. Y.	23

Bed Bottom,—Spring .	J. J. McCormick, .	Paterson,	N. J.	30
———————	Joseph Stevens, .	Lowell,	Mass.	23
Bedstead,—Portable Folding	H. W. Eastman, .	Baltimore,	Md.	9
Bedsteads,—Fracture	Ezekiel Daniels,	Owego,	N. Y.	9
Bee-hives, .	Alexander Clow, .	Waterford,	Penna.	16
——— .	Samuel Ide, .	East Shelby,	N. Y.	2
——— .	Orlando Miller, .	Girard,	Penna.	2
——— .	Hugh H. Whitney,	Waterford,	"	30
Blasting Powder,—Composit. for	Thomas & Emanuel,	Catasauqua,	"	9
Boats,—Attaching and Detach.	Hunter Davidson,	U. S. Navy,		9
Boat Detaching Apparatus,	Wm. M. Van Wagener,	Newark,	N. J.	16
Boilers for Hot Water Apparat.	Edward Horalek,	City of	N. Y.	9
Bolting Chests, .	Joseph Bell, .	Belleville,	Ill.	9
Bookcase, .	Anthony Lamb, .	Cambridge,	Mass.	16
Boot Crimp, .	J. G. Whittier, .	Attica,	Ind.	2
—— and Pantaloon Jack,	Clough & Day, .	Brooklyn,	N. Y.	30
Boots and Shoes, .	A. O. Crane, .	Hoboken,	N. J.	23
—————— .	L. and S. B. Holden,	Woburn,	Mass.	2
Boring Machine, .	E. P. Drake, .	Greenbush,	N. Y.	23
Bracelets, .	Henry Kipling, .	City of	"	2
Brake,—Wagon .	Josiah Long, .	Morristown,	Ind.	2
Brakes for Carriages,	J. E. Briggs, .	Watertown,	N. Y.	2
Brick Machines (2 patents),	John Caswell, .	Syracuse,	"	16
—————— .	W. S. Watson, .	Madison,	Ind.	2
Bridges,—Truss Frames of	J. W. Murphy, .	Philadelphia,	Penna.	30
Brush,—Scrubbing	Wm. L. Haller,	"	"	30
Buckles, .	John E. Smith, .	Waterbury,	Conn.	23
Bullets,—Machine for Making	Richard Gornall,	Baltimore,	Md.	30
Buoying Vessels,—Apparat. for	E. Goulard, .	City of	N. Y.	2
Button Fastenings,	W. Kuhlenschmidt,	"	"	23
——— Fasteners, .	Joseph Lofvendahl, .	East Boston,	Mass.	16
Cannon Balls,—Protect. Vessels	Francis Comtesse,	City of	N. Y.	23
Carpet Fastener, .	M. D. and S. A. Snyder,	Clarendon,	"	16
——— Linings, .	J. R. Harrington,	City of	"	23
Carriage Hubs,—Boxes of	J. A. Cramer, .	Brooklyn,	"	2
Cartridge Loaders,	Edward Maynard,	Washington,	D. C.	2
Carriage Tops,—Braces for	B. F. Hooper, .	Birmingham,	Conn.	9
Carriages,—Children's	Crandall & Conover,	City of	N. Y.	2
Car Ventilator, .	J. B. Bausman, .	Rochester,	Penna.	9
Cheese Presses, .	Calvin Auborn, .	Watertown,	N. Y.	9
—————— .	John Patterson, .	Indianapolis,	Ind.	23
——— Vat, .	D. W. Maples, .	Homer,	N. Y.	30
———— Operator, .	C. M. Wilkins, .	W. Andover,	Ohio,	2
Cider Mills, .	Saml. & R. W. Caldwell,	Chillicothe,	"	16
Clock Escapement, .	John C. Pitel, .	Meriden,	Conn.	23
Cloth,—Tentering and Drying	J. S. Winson, .	Providence,	R. I.	9
Clothes Dryer, .	Ezra Buss, .	Yellow Springs,	Ohio,	2
————— .	Duane Hull, .	Newburgh,	N. Y.	9
————— .	Chas. Robinson, .	Cambridgeport,	Mass.	23
——— Frame, .	L. L. Knight, .	Barre,	"	16
——— Wringer, .	Ezariah Spaulding, .	Morrisville,	Vt.	16
——————— to a Tub,—At.	David Lyman, .	Middlefield,	Conn.	2
Coal and Ores,—Desulphurizing	J. I. Storer, .	Philadelphia,	Penna.	9
—— Sifter, .	David J. Starrett,	Thomaston,	Me.	30
—— Scuttle, .	J. G. Treadwell, .	Albany,	N. Y.	23
Coffee Pots, .	H. W. Mosher, .	Warren,	Ill.	23
————— .	David Stewart, .	Annapolis,	Md.	9
—— Steeper, .	R. S. Sanborn, .	Sycamore,	Ill.	2
Copying Presses,—Portable	J. H. Atwater, .	Providence,	R. I.	2
Core Carriages, .	Samuel Fulton, .	Conshohocken,	Penna.	16
Cork-cutting Machines, .	Alexander Millar, .	City of	N. Y.	9
—— Machines, .	"	"	"	16

Corn Planters,—Hand .	S. P. Briggs, .	Saratoga Spr's,	N. Y.	30
——— .	W. C. Ford, .	West Salem,	Ohio,	9
——— .	J. M. Foy, .	FountainGreen,	Ill.	16
——— .	David Humphreys,	Cincinnati,	Ohio,	16
——— .	C. K. Myers, .	Pekin,	Ill.	23
——— .	Powers Ritchey,	Hamilton,	"	16
——— .	Stone & Archibald, .	Wapello,	Iowa,	16
—— Stalks,—Cutting Standing	T. J. Freeman, .	Heyworth,	Ill.	2
Cotton Cultivators, .	G. W. Rice, .	Demopolis,	Ala.	16
——— Presses, .	Tilmon Gilbert, .	Natchez,	Miss.	9
Couplings,—Car .	F. B. Hall, .	Hartford,	Conn.	30
Cranks,—Avoid. Dead Centres	Turner Williams,	Providence,	R. I.	2
Cultivators, .	C. W. Emerson, .	Albany,	N. Y.	23
——— .	O. W. Goslee, .	Glastenbury,	Conn.	2
——— .	J. A. Spear, Jr., .	Manchester,	Penna.	9
——— .	Isaac Stout, .	Tremont,	Ill.	16
——— .	Wm. F. Veber, .	Bowling Green,	Ohio,	2
Cultivator Teeth, .	Wm. Morrison, .	Chadd's Ford,	Penna.	16
Curtain Fixture, .	George Gatty, .	City of	N. Y.	16
——— Roller,—Shade or	Langdon Sawyer,	Springfield,	Vt.	9
Cylinders,—Casting Copper	Freeborn Adams, .	Somerville,	Mass.	30
Deep Sea Sounding,—Cup for	W. P. Trowbridge,	Washington,	D. C.	16
Derricks,—Floating .	G. W. Brush, .	Brooklyn,	N. Y.	9
Disinfecting Foul Air in Vessels,	Alois Peteler, .	New Brighton,	"	9
Door Alarms, .	Curtis & Tufts, .	Charlestown,	Mass.	9
—— Bolt, .	Benj. Russell, .	Brooklyn,	N. Y.	9
—— Lock, .	Solomon Fry, .	Monongahela,	Penna.	30
—— Spring, .	J. O. Blythe, .	Germantown,	"	2
Drain Tiles, .	Adam Newkumet, .	Philadelphia,	"	16
Excavator, .	Archibald Kirby,	Paris,	Ill.	30
Excavators, .	Wm. Randall, .	Uxbridge,	Canada,	2
Extracts under Pressure,—mak.	A. A. Burlingame,	City of	N. Y.	9
Eyelet Machines, .	S. J. Smith, .	"	"	16
Faucets, .	J. S. Davison, .	Cranberry,	N. J.	16
——— .	John Neumann, .	City of	N. Y.	30
Feathers,—Dressing	Samuel Orr, .	E. Springfield,	Ohio,	9
Felting Machines, .	G. N. Bronson, .	New Milford,	Conn.	16
Filters, .	George Norris, .	City of	N. Y.	30
Fire Arms, .	W. McCord, .	Sing Sing,	"	2
———,—Breech-load. (2 pat.)	J. H. Merrill, .	Baltimore,	Md.	9
———,—Locks of .	Prince Hiller, .	Mattapoisett,	Mass.	30
—— Grates, .	Joseph Tiberi, .	St. Louis,	Mo.	2
Floor Clamp, .	J. L. Clough, .	Suffield,	Conn.	23
Fly Wheels,—Arranging	H. B. Peck, .	Wolcott,	N. Y.	2
Fog Bells,—Operating .	John Haynes, .	Pembroke,	Me.	2
Fracture Apparatuses,	Theodore Burr, .	Battle Creek,	Mich.	30
Fringe,—Making .	L. D. Valetton, .	City of	N. Y.	2
Garden Hoe, .	Jonathan Howard,	W Bridgewater,	Mass.	9
Gas,—Appar. for Naphthalizing	W. H. Gwynne, .	City of	N. Y.	30
—— Burners, .	Leffingwell & Thompson,	Newark,	N. J.	2
——,——— for Purifying	John Danks, .	Troy,	N. Y.	23
—— from Wood,—Retorts for	Mark Levy, .	City of	"	9
—— Meters, .	Samuel Glegg, .	Putney,	Engl'd,	16
—— Retorts, .	S. H. and M. C. Walker,	Boston,	Mass.	9
———,—Construction of	John M. Gallacher, .	Roxbury,	"	30
Gates, .	G. C. Flagg, .	Tanktown,	Ohio,	9
Geometrical Lines, &c.,—Deter.	R. B. Light, .	Dunkirk,	N. Y.	9
Gins,—Cotton .	J. F. Brown, .	Columbus,	Ga.	23
Grain Cradles, .	Daniel H. Viall, .	Schaghticoke,	N. Y.	30

Grain Separators, .	George Lull, .	Hardin,	Iowa,	16
———— .	Andrew Hunter, .	Solano co.,	Cal.	9
———— .	Linus Merrill, .	Janesville,	Wis.	9
———— .	Turner & Vaughn, .	Cuyahoga Falls,	Ohio,	9
———— .	Wirtz & Swift, .	Hudson,	N. Y.	16
Halter Ring, .	L. C. Chase, .	Boston,	Mass.	30
Hammers, &c.,—Handle for	Thomas Phillips,	Ann Arbor,	Mich.	9
Harness,—Safety Hook for	Henry Beagle, Jr., .	Philadelphia,	Penna.	9
Harrow Frames, .	J. Brainerd and others,	Cleveland,	Ohio,	2
Harvesters, .	Adam Pritz, .	Dayton,	"	16
————,—Raking Attach.	G. E. Chenowith,	Baltimore,	Md.	9
————,—Rakes for .	Chester Bullock, .	Jamestown,	N. Y.	23
Harvesting Machines,	T. C. Hargrave,	Schenectady,	"	30
———— .	F. H. Manny, .	Rockport,	Ill.	30
————	Thomas S. Whitenack,	Easton,	Penna.	30
Hats and Caps,—Shaping, &c.,	A. L. Bayley, .	Amesbury,	Mass.	9
Heating Buildings,—Furnaces	Joseph Leeds, .	Philadelphia,	Penna.	2
Hemp Brakes, .	J. R. McDonald, .	Fayette,	Mo.	2
Hinges,—Making Butt	Brown & Van Gieson,	Waterbury,	Conn.	9
Hoes,—Handle for .	Samuel Reynolds, .	Duquesne Bor.,	Penna.	23
Hooks and Eyes, .	A. C. Mason, .	Springfield,	Vt.	9
Horse-shoe Machine, .	D. N. Allard, .	McConnelsville,	Ohio,	9
Horse-shoes,—Toe Calkin for	C. H. Perkins, .	Providence,	R. I.	9
Ice Cream Freezers, .	H. B. Masser, .	Sunbury,	Penna.	23
Inkstands, .	J. W. Ross, .	Boston,	Mass.	30
Iron Castings,—Reducing, &c.,	C. R. Ely, .	Shelden,	Vt.	2
Key Fastener, .	E. H. Bailey, .	Philadelphia,	Penna.	9
——,—Edge .	Edwin Campbell, .	Bath,	Me.	30
Knitting Machines,	J. K. and E. E. Kilbourn,	Norfolk,	Conn.	9
Ladder, .	George Aldrich, .	Armada,	Mich.	30
——— Hook,—Adjustable	W. T. Farrar, .	Concord,	Mass.	9
Lamps, .	J. E. Ambrose, .	Lena,	Ill.	23
——— .	M. L. Callender,	City of	N. Y.	23
——— .	J. T. Clegg, .	Philadelphia,	Penna.	2
——— .	Frederick Heidrich,	"	"	2
——— .	Anson Judson, .	Brooklyn,	N. Y.	9
——— .	Stuber & Frank,	Utica,	"	23
——— .	Joseph Thomas, .	City of	"	23
Lanterns, .	E. B. Coffin, .	Johnston,	R. I.	23
——— .	G. H. Magersuppe, .	City of	N. Y.	2
Lath Machines, .	Albert Gummer,	Indianapolis,	Ind.	16
Leather,—Finishing .	Wm. Ellard, .	Woburn,	Mass.	2
Linen Smoother, .	Horatio Rodd, .	Chestnut Hill,	Penna.	9
Locks (2 patents), .	Henry Hartwig, .	City of	N. Y.	30
Lock,—Combination	Fred. W. Alexander,	Baltimore,	Md.	30
Looms, .	George Crompton, .	Worcester,	Mass.	23
——— .	George Copeland,	North Gray,	Me.	9
——— .	John Shinn, .	Leverington,	Penna.	30
———,—Hair Cloth	John Nobbit, .	Philadelphia,	"	9
———,—Let-off for .	W. H. Gray, .	Dover,	N. H.	9
———,—Pickers for	Samuel Boorn, .	Lowell,	Mass.	9
———,—Power .	Thomas King, .	West Farms,	N. Y.	16
Match Boxes, .	S. W Francis, .	City of	N. Y.	30
Meat,—Preserving .	D. E. Somes, .	Biddeford,	Me.	9
Mill Picks, .	Peter Faver, .	City of	N. Y.	9
——— .	Benjamin Hostler, .	Brookfield,	N. Y.	30
Mining Pan, .	John A. Brock, .	Chicago,	Ill.	23
Mosquito Net, .	Voorhis & Whiteman,	City of	N. Y.	9
Motion,—Transmitting	J. W. Howlett, .	Greensboro',	N. C.	9

Mowing Machines, .	E. F. and J. Herrington,	W. Hoosick,	N. Y.	9
————————	J. H. Rible, .	Dayton,	Ohio,	2
Muzzles for Dogs, &c., .	C. F. Schmidt, .	Williamsburgh,	N. Y.	2
Newspaper Files, .	H. S. White, .	Newport,	R. I.	2
Oil Cans,—Cap for .	J. H. Breckinridge, .	Meriden,	Conn.	2
Oils,—Distilling .	Abraham Quinn,	City of	N. Y.	9
——,—Distilla. of Hydro-carbon	J. J. Johnston, .	Alleghany,	Penna.	9
Ordnance,—Breech-loading	J. S. Butterfield,	Philadelphia,	"	30
Pantaloons,—Guides for Cutting	Ramsey & Smith, .	Clinton,	Penna.	23
Paper,—Letter .	T. H. Dodge, .	Washington,	D. C.	23
——— Stock,—Preparing .	A. Randel, .	City of	N. Y.	30
Photographic Medals,	H. E. Copely, .	Waterbury,	Conn.	2
Photographs on Paper,—Varnish.	D. W. S. Rawson, .	Galena,	Ill.	2
Piano-fortes,—Square	C. F. Chickering,	City of	N. Y.	23
Picture Frames,—Enameling	Sperry & Sherwood, .	"	"	2
Pipe,—Moulds for Casting	Samuel Fulton, .	Conshohocken,	Penna.	16
—— Joint, .	A. C. Jones, .	Philadelphia,	"	23
Pistols,—Gun Stocks to	E. B. Savage, .	Cromwell,	Conn.	9
Plough. & Till. Land (3 pats.),	John Fowler, .	Leeds,	Engl'd,	9
Ploughs, .	G. W. Cooper, .	Palmyra,	N. Y.	16
——— .	J. B. Cooper, .	Brooklyn,	"	9
——— .	Valentine Felker,	Carmel,	Me.	30
——— .	E. J. Fraser, .	Kansas,	Mo.	23
——— .	H. F. Mann, .	Laporte,	Ind.	16
——— .	Partlett & Thompson,	Elmira,	N. Y.	2
——— .	Franklin Traxler,	Salem,	Mich.	16
———,—Steam .	John K. Smith, .	Trenton,	N. J.	23
———,—Subsoil	James McCollum,	Brownsville,	Ala.	23
Potatoes,—Machines for Digging	Conover & Spring, .	City of	N. Y.	30
Power,—Transmitting	T. J. Lowry, .	Conneautsville,	Penna.	16
Presses, .	Huddleston & Harrison,	Lawrence,	Kansas,	9
———,—Printing	F. L. Bailey, .	Boston,	Mass.	30
———————— .	G. P. Gordon, .	Brooklyn,	N. Y.	23
Pumps, .	Harvey Locke, .	South Boston,	Mass.	30
——— .	G. W. Martin, .	Morrisania,	N. Y.	9
——— .	A. M. Perkins, .	Springfield,	Mass.	2
———,—Operating .	James Armstrong, .	Dobbinsville,	N. C.	16
———,—Rotary .	C. L. Johnston, .	Little Falls,	N. Y.	9
Railroad Cars,—Stop. and Start.	J. A. Emerick, .	Philadelphia,	Penna.	23
——— Chair and Splice,	E. F. Barnes, .	Brooklyn,	N. Y.	23
——— Indicator, .	M. T. Ridout, .	Milwaukie,	Wis.	9
——— Rails,—Joints for	Reymond French,	Seymour,	Conn.	16
———,—Splicing Rails for	B. A. Mason, .	Newport,	R. I.	16
Rakes,—Hay .	Wm. Deckman, .	Canton,	Ohio,	16
———,—Horse .	Jonah Crites, .	Orrville,	"	2
Reading Desk,—Night	John Rogowiski,	City of	N. Y.	23
Reapers and Mowers, .	D. Hitchings, .	Richfield,	"	30
Reels, .	Caroline H. Carnes,	City of	"	9
Refrigerator, .	C. G. Page, .	Washington,	D. C.	2
Rigging Clasp, .	George W. Soule,	Freeport,	Me.	30
———,—Setting up Ships	Barton Ricketson, .	New Bedford,	Mass.	2
Rocking Horse, .	A. Christian, .	City of	N. Y.	2
Roofing Cloth,—Making .	D. S. Anderson, .	Trenton,	N. J.	23
Rotary Engines, .	J. B. Root, .	Battle Creek,	Mich.	30
——— Motion,—Registering	F. B. Hall, .	Hartford,	Conn.	23
Salt Kettles,—Construction of	O. W. Seely, .	Albany,	N. Y.	9
Sash Fastener, .	J. C. Butterworth, .	Providence,	R. I.	16
Saw Plates,—Hardening	James Dodge, .	Waterford,	N. Y.	16
Saw-set, .	Amos Call, .	Springfield,	Mass.	30

Sawing Machines,—Cross-cut	S. S. Dice,	Stark co.,	Ohio,	2
Screws and Tacks,—Head for	G. R. Wilmot,	West Meriden,	Conn.	9
Seed Planters,	Daniel Broy,	Canton,	Mo.	23
———	T. W. White,	Milledgeville,	Ga.	16
———	L. R. Wright,	Cohoes,	N. Y.	16
—— Drills,	G. W. Nevill,	Bath,	Ill.	16
Seeding Machines,	Bacon & Fowler,	Ripon,	Wis.	16
———	C. W. Cahoon,	Portland,	Me.	9
———	George Harlan,	Brownsville,	Ind.	30
———	T. S. Mills,	Iberia,	Ohio,	23
Sewers,—Inlet for	W. H. Short,	Brooklyn,	N. Y.	9
Sewing,—Finger Shield for Hand	A. H. Downer,	City of	"	2
———,—Hemmers for Hand	J. O Whitcomb,	"	"	9
——— Machines,	A. H. Boyd,	Rockville,	Mass.	2
———	Theodore Burr,	Battle Creek,	Mich.	9
———	W. C. Hicks,	Boston,	Mass.	16
———	G. H. Mallory,	City of	N. Y.	2
———	H. L. Shaw,	Milan,	Ohio,	9
———	J. D. Alvord,	Bridgeport,	Conn.	16
Shearing Sheep-skins,	Wm. D. Cutler,	Millbury,	Mass.	30
Shot Pouches,	C. Johnston,	Clarksville,	Mo.	16
Shuttle Fastener,	Wm. M. Griscom,	Philadelphia,	Penna.	30
Signs,	W. B. Little,	City of	N. Y.	30
Skates,	Bassford & Carpenter,	"	"	30
———	J. A. De Brame,	"	"	9
———	G. S. Curtis,	Chicago,	Ill.	23
———,—Roller	Henry Pennie,	Brooklyn,	N. Y.	9
Skirts,	T. B. DeForest,	Birmingham,	Conn.	2
———,—Manufacturing Skeleton	R. J. Mann,	Brooklyn,	N. Y.	2
Smoking Tubes,	Boeklen & Staehlen,	"	"	2
Soaps,	W. E. Dawson,	Lynchburg,	Va.	9
Spading Machines,—Rotary	Donald Mann,	Rochester,	N. Y.	23
Spike Machines,	James H. Swett,	Pittsburgh,	Penna.	30
Spinal Curvat's,—Reduc. (3 pat.)	C. F. Taylor,	City of	N. Y.	9
Spinning Frames,	F. S. Stoddard,	Litchfield,	Conn.	23
——— Machines,—Bobbins for	J. A. Bazin,	Canton,	Mass.	9
——— Machinery,	George Goulding,	Watertown,	N. Y.	16
———	Chas Hardy,	Biddeford,	Me.	9
Springs,—Carriage	P. G. Gardiner,	City of	N. Y.	2
Stable Broom,	Richmond & Wright,	"	"	16
Stave Machines,	James Nevison,	Morgan,	Ohio,	2
Steam and Air,—Combining &c.	Rogers & Black,	Philadelphia,	Penna.	23
——— Boilers,	Francis B. Blanchard,	Brooklyn,	N. Y.	2
———	G. W. Rains,	Newburg,	"	30
———,—Combustion in	Tiffany & Heermance,	City of	"	2
———,—Feed water ap.	L. X. Gargan.	Paris,	France,	16
———	W. A. Lightfall,	City of	N. Y.	9
———,—Furnaces for	James Millholland,	Reading,	Penna.	16
———,—Gas Generat.	John Laing,	Hoboken,	N. J.	9
———,—Safety Plugs	J. R. Robinson,	Boston,	Mass.	30
——— with water,—sup.	Rensalier Jadwin,	Grafton,	Ohio,	16
———,—low wat. alarm	Adam Carr,	Paterson,	N. J.	16
———,——— indic.	S. W. Warren,	Brooklyn,	N. Y.	30
——— Cock,	Alfred Swadkins,	South Boston,	Mass.	30
——— Engines,	J. R. Armstrong,	Kendallville,	Ind.	16
———	J. R Robinson,	Boston,	Mass.	30
———	S. H. Whitmore,	Cincinnati,	Ohio,	2
———,—Feed water	Benjamin Crawford,	Pittsburgh,	Penna.	2
———,—Pistons of	L. B. Batcheller,	Rochester,	N. Y.	30
———	J. O. Haight,	Albany,	"	9
——— Pump,	Martin Wilcox,	Middlebury,	Ohio,	2
——— Trap,	John Gunn,	Worcester,	Mass.	23
Stoves,	Bibb & Augee,	Baltimore,	Md.	30

Stoves, .	John Magee, .	Lawrence,	Mass.	23
———,—Cooking	A. C. Barstow, .	Providence,	R I.	30
——————— .	H. H. Huntley, .	Cincinnati,	Ohio,	2
———————	Wm. Resor, .	"	"	16
Straw Cutters, .	O. B. Wattles, .	Mooresboro,	N. C.	16
Street Cleaning Machines,	Wm. H. Hope, .	Washington,	D. C.	30
———————	Loughlin Conroy, .	City of	N. Y.	16
Stump Extractor, .	Frederick Ketler,	Milwaukie,	Wis.	30
Suspender Buttons, .	Edwin Smith, .	Naugatuck,	Conn.	16
Tablets, .	Wenisch & Berky,	Tompkinsville,	N. Y.	16
Telegraph,—Electro-magnetic	A. E. Parks, .	Brooklyn,	"	2
Telegraphic Cable,	T. W. Evans, .	Philadelphia,	Penna.	30
Temples, .	Hoffman & Graichen,	Clinton,	Mass.	9
Tenoning Machine,	Bain & Brown, .	Richmond,	Ind.	16
Thimbles, .	B. W. Hood, .	Pawtucket,	Mass.	9
Thread-winding Guides,	T. B. DeForest, .	Birmingham,	Conn.	9
Threshing Cylinder, &c.,	Chas. Bailey, .	Batavia,	Ill.	23
——— and Cleaning Clover,	Wm. Rowe, .	Charlestown,	Va.	30
——— Separating Grain,	Cyrus Roberts, .	Belleville,	Ill.	16
Tires for Locomotive Wheels,	Wm. W. Snow,	Jersey City,	N. J.	23
Training Horses, &c., to Rack,	Commodore Daniels, .	Barnwell C. H.,	S. C.	30
Turpentine and Resin,—Manuf.	Henry Napier, .	Brooklyn,	N. Y.	9
Valve Arrangement, .	Lewis Eikenberry, .	Philadelphia,	Penna.	16
Valves for Pumps,	C. A. Clark, .	Pulaski,	Iowa,	16
Vegetable Cutter, .	J. R. Whittemore, .	Chicopee Falls,	Mass.	2
Vessels,—Ascer. Curv, of Keel of	H. E. Toule, .	Exeter,	N. H.	23
Vise, .	Louis Tilliers, .	Mott Haven,	N. Y.	16
Wagon Brakes, .	Porter Seward, .	Chaseville,	N. Y.	9
——— Locks, .	Thomas Service, .	Utica,	Penna.	16
Wagons,—Tailboards of	J. O. Farrell, .	Boston,	Mass.	23
Washing Machine, .	Henry Bailey, .	Columbia,	Me.	23
———————	Henry Behn, .	City of	N. Y.	30
——————— .	Wm. Brannan, .	Gloucester,	N. J.	30
———————	R. W. George, .	Richmond,	Me.	2
——————— .	G. W. and P. W. Gould,	Evans,	N. Y.	30
———————	Hutchings & Leach,	Penobscot,	Me.	2
——————— .	E. T. Shepard, .	Gallipolis,	Ohio,	23
———————	James M. Tolley,	Big Lick,	Va.	30
Watch Escapement, .	G. P. Reed, .	Roxbury,	Mass.	9
——— and Locket Rims,—Mak.	D. B. Weite, .	Providence,	R. I.	23
Water Cooler,—Refrigerator and	Anderson Godley, .	Ithaca,	N. Y.	9
——— Elevators, .	Ransom Bartle, .	Independence,	Iowa,	9
——————— .	Hudson & Billings, .	Cleveland,	Ohio,	30
——————— .	Hunt & Kennedy,	Galesburgh,	Ill.	2
——————— .	Calvin Shepherd, .	Chenango,	N. Y.	23
——— Pipes, .	Arcalous Wyckoff,	Elmira,	"	16
———,—Apparat. for Purifying	Jacobs & Wilkinson,	St. Louis,	Mo.	2
——— Wheels, .	Wm. Dripps, .	Coatsville,	Penna.	9
——————— .	Chas. Greenawalt, .	Seiberlingville,	"	23
——————— .	Haag & Smith, .	Bernville,	"	16
——————— .	Kenyon & Brown, .	Hopkinton,	R. I.	30
——————— .	I. D. Seely, .	Milford,	N. Y.	9
Wheels,—Propelling .	Comstock & Glidden,	Milwaukie,	Wis.	30
Wheelwrights Machine,	Curtiss Luther, .	Newbury,	Ohio,	16
Wicks,—Trimming .	A. R. Turner, .	Malden,	Mass.	2
Wrench, .	G. W. Martin, .	Morrisania,	N. Y.	16

EXTENSIONS.

Bedsteads,—Folding .	T. B. Bleecker, .	City of	N. Y.	16
Cables,—Work. & Stop. Chain	Thomas Brown,	London,	Engl'd,	16

RE-ISSUES.

Amalgamators,—Gold .	Wyckoff & Fell, .	Brooklyn,	N. Y.	9
Air Engines, .	Philander Shaw,	Boston,	Mass.	23
Bonnet Fronts, .	G. A. Cox, .	Brooklyn,	N. Y.	23
Cotton Gins, .	Campbell & Brown,	Columbus,	Miss.	2
Envelopes,—Making .	E. W. Goodale, .	Clinton,	Mass.	16
Harvesters, (2 patents)	Huntley Bowman & Co.,	Brockport,	N. Y.	16
————,—Grass .	A. W. Morse, .	Eaton,	"	2
Hoop Machine, .	Amer. Hoop Mach. Co.,	Fitchburg,	Mass.	16
Inkstands,—Fountain .	Francis Draper, .	E. Cambridge,	"	2
Locks, .	L. F. Munger, .	Rochester,	N. Y.	2
Pipes,—Hot Air .	C. F. J. Colburn, .	Newark,	N. J.	2
Seed Drills, .	Jonathan Smith,	Tiffin,	Ohio,	2
Steam Boilers,—Combustion in	J. C. Tiffany, .	City of	N. Y.	16

DESIGNS.

Stove,—Cooking .	N. S. Vedder, .	Troy,	N. Y.	2
Stoves (3 cases), .	W. W. Stanard,	Buffalo,	"	9
Window Glass, .	Chas. Prosbt, .	Hudson City,	N. J.	9

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 20, 1861.

John Agnew, Vice President, in the chair.

John F. Frazer, Treasurer.
Frederick Fraley, Corresponding Secretary.
Isaac B. Garrigues, Recording Secretary. } Present.

The minutes of the last meeting were read and approved.

Letters from the Institution of Civil Engineers, London, and from the Philadelphia Society for the Promotion of Agriculture, were read.

Donations to the Library were presented by the Royal Society, the Royal Astronomical Society, the Institution of Civil Engineers, the Institute of Actuaries, and the Society of Arts, &c., London; the Oesterreichischen Ingenieurs Veriens, Vienna, Austria; the Smithsonian Institution, Washington, D. C.; Messrs. Field & Ticknor, Boston, Mass.; Capt. Geo. G. Meade, Corps U. S. Topographical Engineers; and Messrs. John W. Nystrom, Prof. John F. Frazer, Prof. John C. Cresson, and Jos. Hutchinson, of Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of May.

The Board of Managers and Standing Committees reported their minutes.

The Actuary reported that the standing Committee on Meteorology have organized by electing Mr. James S. Whitney chairman for the ensuing year, and appointing the third Thursday afternoon of each month for their stated meetings.

The amendments to the Constitution proposed at the last meeting were discussed, amended, and adopted unanimously.

Mr. Howson exhibited one of Wootten's Patent Hydrostatic Pressure Gauges. This instrument, a further description of which will be given in a future number, is capable of indicating with accuracy hydrostatic pressures ranging as high as 10,000 lbs. per sq. inch.

Mr. Howson also exhibited a specimen of a new Breech-loading Rifle, invented and patented by C. Sharps, Esq., the well-known firearm manufacturer of this city.

The barrel is arranged to slide horizontally on the stock, and is operated by a lever which forms the trigger guard, this lever when the barrel is closed against the stationary breech being entirely out of the way, and wholly embedded in the stock with the exception of that portion which forms the guard.

The ammunition used is the well-known metallic cartridge, which has the bullet at one end, an enlargement containing the detonating material at the opposite end, and an intervening charge of powder.

After sliding out the barrel, the cartridge is inserted into the bore, the barrel is moved back by the lever, the action of which not only moves the barrel with its enlargement contained in a recess formed in the breech, but also serves to lock the barrel so firmly that it may be considered a part of the breech.

A hammer with a blunt pointed nipple strikes the edge of the enlargement of the cartridge and explodes the charge.

On moving out the barrel preparatory to reloading the same, the spent cartridge is retained by a small spring catch bearing against the edge of the enlargement of the spent cartridge, which is thus withdrawn from the barrel without any exertion or delay.

A very simple and ingenious device is attached to the stock for locking the lever when the barrel bears against the breech, the unlocking of the lever being accomplished by that movement of the operator's hand which is required to depress the lever and move out the barrel.

A sliding catch is used for guarding the hammer and preventing it from acting on the cartridge when any sudden movement or jerk of the fire arm takes place, thereby preventing unintentional discharges.

A very neat adjustable sight is attached to the barrel, and is so connected with a graduated and numbered quadrant that it can be adjusted and locked in a position to suit any desired range.

From private experiments recently made at Atlantic City, it has been found that the charge from this arm will take effect at a distance of three-quarters of a mile, and that good aim can be taken at any object one-quarter of a mile distant, the load being effective against a body of men half a mile distant.

The accuracy and precision of the arm may be judged from the fact that the inventor at a distance of eighty yards fired twenty balls through a target less than one foot square, in two minutes and three-quarters, each discharge taking effect, and a reasonable time being occupied in taking aim. The arm can, however, if desired, be discharged fifteen times per minute.

BIBLIOGRAPHICAL NOTICE.

Pocket-Book of Mechanics and Engineering, containing a Memorandum of Facts and Connection of Practice and Theory. By John W. Nystrom, C.E. 5th edition, Philadelphia: J. B. Lippincott & Co., 1861.

Mr. Nystrom sends us another excellent little book of mechanical data and memoranda, for which he has made himself celebrated. Our mechanics will find this manual very convenient, well-arranged, and apparently accurate. We have to remark, however, that the French metre given on page 73 as 39·38091 inches, is, by the determination of the Coast Survey, which is an authority in America, 39·3685. This should be corrected. F.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.

May.—The mean temperature of the month was 59·38°, nearly five degrees below that for May of last year, and two and a half degrees less than the average for ten years past. The highest thermometric indication was 83° on the afternoon of the 27th, but the 26th was the warmest day of the month, its mean temperature being 73·7°. The coldest day was the 3d, of which the mean temperature was 40°; the lowest (36°) was reached on the morning of the 2d of the month.

The greatest daily oscillation of temperature was 27° on the 5th; the average oscillation for the month 19·55°, nearly 3° greater than the mean for the last ten years. The least daily oscillation was 8° on the 20th, when rain fell nearly all day. The greatest daily range—that is to say, the greatest mean difference between two successive days—was 10½° between the 20th and 21st; the least was 1° between the 23d and 24th. The mean daily range for the month was 5·06°, nearly half a degree less than usual.

The force of vapor and relative humidity were both considerably less than the average, as will more fully appear in the annexed table of comparisons.

During the month, a greater quantity of rain fell than in the corresponding month in any year since 1854, when about one inch more fell. The amount in May, 1854, was 7·299 inches, in May, 1861, 6·240 inches. The number of days on which rain fell (13) was six less than in May, 1860, but was just equal to the average number for ten years. More than half of the rain for the month fell between noon on the 3d and the night of the 6th. In that time 3·420 inches fell.

The sky was entirely clear, or free from clouds, on six days, and completely covered on two days of the month at the hours of observation.

The atmospheric pressure was greatest (30·132 inches) on the morning of the 31st, and least (29·096 inches) on the afternoon of the 27th, making the range for the month 1·036 of an inch. The minimum reading was the lowest observed during the month of May for ten years. The nearest approach to it was in May, 1858, when the lowest was 29·386 inches. Before or after this great depression there was no very notable atmospheric disturbance. The greatest mean daily range for the month was 0·413 of an inch, and occurred between the 27th and 28th; the average for the whole month was 0·156 of an inch.

A Comparison of some of the Meteorological Phenomena of May, 1861, *with those of May,* 1860, *and of the same month for ten years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	May, 1861.	May, 1860.	May, 10 years.
Thermometer.—Highest, . .	83°	90°	90°
" Lowest, . .	36	44	35
" Daily oscillation,	19·55	17·20	16·86
" Mean daily range,	5·06	5·20	5·53
" Means at 7 A. M.,	55·40	59·66	58·17
" " 2 P. M.,	65·74	71·03	69·38
" " 9 P. M.,	57·00	61·57	61·15
" " for the month,	59·38	64·09	62·90
Barometer.—Highest, . .	30·132 in.	30·050 in	30·338 in.
" Lowest, ...	29·096	29·479	29·096
" Mean daily range, .	·156	·100	·124
" Means at 7 A. M., .	29·744	29·828	29·832
" " 2 P. M., .	29·691	29·787	29·797
" " 9 P. M., .	29·726	29·815	29·820
" " for the month,	29·720	29·810	29·816
Force of Vapor.—Means at 7 A. M.,	·282 in.	·395 in.	·353 in.
" " " 2 P. M.,	·284	·421	·373
" " " 9 P. M.,	·297	·420	·374
Relative Humidity.—Means at 7 A. M.,	63 per ct.	76 per ct.	72 per ct.
" " " 2 P. M.,	44	57	52
" " " 9 P. M.,	63	76	69
Rain, amount in inches, . .	6·240 in.	3·589 in	4·400 in.
No. of days on which rain fell,	13	19	13
Prevailing winds, . . .	N 72°48′ W ·257	N 59°2′ E ·070	N 71°34′ W ·116

Spring.—The season just closed was the coldest of the last three springs. The mean temperature was about one degree less than that of the Spring of 1860, but was very close to the average for the last ten years. The maximum indication was 88° on the 24th of April, and the minimum was 16° on the 18th of March, making the quarterly range of temperature 72°.

The last ice of the season was formed on the 22d of March, and the last snow fell on the 17th of April. In 1860, the last snow fell on the 25th of April, and the last ice was found on the morning of the

26th of the same month. The Delaware River was not closed by ice below the city during the whole winter, and the Schuylkill, below the dam, was closed for two or three days only.

The changes of temperature from day to day were greater than usual, being nearly half a degree above the average.

The force of vapor, relative humidity, and number of rainy days were less than usual, while the quantity of rain was nearly two and a half inches above the average of the season, and nearly six inches more than the quantity which fell in the Spring of 1860.

The average atmospheric pressure was almost identical with the Spring of last year and with the average pressure for the past ten years. The maximum pressure (30·386 inches) occurred on the 8th of March, and the minimum (29·096 inches) on the 27th of May, making the range for the quarter 1·290 inches. The greatest daily range of pressure—that is, the greatest mean difference between two successive days—was 0·686 of an inch between the 8th and 9th of March, and the least was 0·028 between the 22d and 23d of April. The mean daily range for the quarter was 0·177, which is a little more than the average for the last ten years.

A Comparison of the SPRING *of* 1861, *with that of* 1860, *and of the same season for* TEN *years, at Philadelphia, Pa.*

	Spring, 1861.	Spring, 1860.	Spring, for 10 years.
Thermometer.—Highest, . . .	88°	90°	90°
" Lowest, . .	16	25	4
" Daily oscillation, .	18·93	18·10	16·21
" Mean daily range, .	6·52	6·00	6·11
" Means at 7 A. M., .	46·77	47·26	46·61
" " 2 P. M., .	58·33	59·98	58·20
" " 9 P. M., .	49·89	51·07	50·48
" " for the quarter,	51·66	52·77	51·76
Barometer.—Highest, . . .	30·386 in.	30·303 in.	30·522 in.
" Lowest, . . .	29·096	29·319	28·884
" Mean daily range, . .	·177	·133	·165
" Means at 7 A. M., .	29·835	29·835	29·830
" " 2 P. M., . .	29·780	29·779	29·785
" " 9 P. M., .	29·816	29·813	29·813
" " for the quarter,	29·810	29·809	29·809
Force of Vapor.—Means at 7 A. M.,	·229 in	·259 in.	·251 in.
" " " 2 P. M., .	·231	·277	·268
" " " 9 P. M.,	·247	·277	·270
Relative Humidity.—Means at 7 A. M.,	66 per ct.	73 per ct.	72 per ct.
" " " 2 P. M.,	45	50	52
" " " 9 P. M.,	64	68	68
Rain and melted snow, . . .	14·293 in.	8·558 in.	11·984 in.
No. of days on which rain or snow fell,	31	42	36
Prevailing winds, ...	N73°18′W ·254	N76°26′W ·119	N73°31′W ·204

JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

AUGUST, 1861.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

The Garonne, and the works executed upon it under the direction of M. BAUMGARTEN. By JOSEPH BENNETT, Esq.

(Continued from page 32.)

Vegetation upon Banks of River.—The banks are clothed with a beautiful vegetation. Among the trees, the willow growth is most abundant; then the poplar; and next the acacia and alder. The willow springs up spontaneously upon the gravel, sand, and slime; the wild willow called "brusquet" with dark green leaves has a spontaneous growth in the alluvium; the cultivated willow, with a white leaf and appearing like the olive in the distance, is planted by the proprietors for props to the vine; the osier, which serves for withes, is cultivated some distance from the shores.

As soon as the gravel banks emerge from mean water, the indigenous poplar appears upon them; it is quite crooked, with hard wood, and much in demand for mechanical structures. It is only suffered to grow in the rear of the tow-paths, as otherwise it would be subjected to the biennial clippings exacted by navigation interests. The white willow was used in the plantations within the works with most success.

Any slip set 1 or $1\frac{1}{2}$ ft. in the ground will grow; shoots of one years growth are the best; though branches of 2 to 3 years growth, ·4 to 4 ins. diameter, are also planted; when set on high ground, their length

should be $2\frac{1}{2}$ to 3 ft., and then the branch may be divided into 4 or 5 saplings. When planted on low ground, or even covered by low water, the head must be left above mean high water; they thrive in all seasons, if the earth is not too dry and parched, and are generally planted between September and May; for in those months the branches may be cut without injury to the trunk and the saplings are most fresh. Sometimes the plantings are made to intercept the silt of November, December, and January freshets, though those planted after the winter succeed the best. When planted to thrive and for profit, they are set 3 feet apart, but for collecting silt or protecting the shore bank they are set closer. The earth thus planted, and in good condition, yields as much as a similar amount with grain, and is called a "jetin."

They are distinguished into high and low cuttings; the trunks of the first grow from 8 to 11 ins. thick to $6\frac{1}{2}$ ft. above ground, and the branches are not allowed to go above this height; they are spaced $6\frac{1}{2}$ to 9 ft. apart; the trunks of the second do not grow over 2 ft. above the ground, with only 5 to 9 branches upon them.

In cultivation, the young branches are cut so that they may not absorb sap, and all shoots and leaves of principal branches are trimmed once a year. The only branches left are those destined to become what are termed "lattes," which are cut every two or three years, either for commerce, when only the lowest and thickest part of the stem is taken, or for wicker-work and plantations, when the full length with all small branches are preserved.

The "lattes" are of four qualities:—1st. Branches 27 ft. long reduced to $24\frac{1}{2}$ ft. and 2 ins. diameter; 13 to the bundle. 2d. Length reduced to 21 ft. and $1\frac{1}{2}$ ins. diameter; 25 to the bundle. 3d. $16\frac{1}{2}$ ft. long, 1 in. diameter, 50 to the bundle. 4th. $11\frac{1}{2}$ ft. long, $\frac{3}{4}$-in. thick, two bundles, 50 in each, a load for a man.

Upon the Rhine the cuttings are made every five years, for lengths of 15 ft. In Holland, seven to eight years are required for a less growth. Such is the advantage of a southern sun and the fertile soil of the Garonne.

Upon 4042 ares = 99·8 acres, in the Isles of Col-de-Fer and Cordès, the mean annual produce was 19,269·85 francs = \$ 3588·4, and reckoning the hay with it, it would reach the sum of \$ 3910.

The mean annual expense was 9680 francs = \$ 1802. The net revenue is then \$ 21·08 per acre.

No account is taken of the future profit arising from 3000 poplars, which border the walks and which will yield 1500 francs per annum, thus giving in all a net revenue of 320 francs per hectare, or \$ 24 per acre.

We have dwelt upon this description under the conviction that the willow may be serviceable in protecting the banks of our own rivers, and on the supposition that it will here find a ready growth in wet gravel or sand.

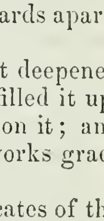
We pass over the elaborate tables showing the importance of the navigation, and proceed to a general description of the works; which may be considered in three separate periods:—the first, before 1826, built simply for the protection of property, without regard to improve-

ments of navigation; the second, in which the system of M. Baudre was initiated, and in which many trials were made in concert with proprietors, who contributed a considerable part of the cost; the third beginning in 1836, comprising the works executed by the state, according to the type of M. Baudre, which had proved successful.

First Period.—The proprietors had, for a long time, defended the banks against corrosions by willow plantations, protected by lines of small stakes, driven by the sledge or beetle and inclined to the banks; they stayed, but did not prevent final destruction. In 1810, M. Vivens, a rich and energetic proprietor, undertook to secure his property, above Tonneins, from the ravages of the St. Germain gravel banks, by irregular lines, formed of strong pine piles secured with wicker-work and an enrockment, and cut at 3 ft. above low water; gradual advances were made into bed of river, thus involving the expense of fortifying the heads from time to time. Successful in this, he afterwards farmed the land above the rocks of Reculay, which was attacked by the gravel of the Sérénat bank, and was authorized in February, 1820, to make some improvements, for which he advanced $ 2200. Prior to this, there had been made eight wiers, each 22 yards long, $43\frac{1}{2}$ yards apart, and inclined 45° to the shore, each costing about $ 200.

He hoped, by cutting a canal in the bank, to have the cut deepened by the water itself; but the freshet of February, 1823, filled it up, and carried away all the lines which directed the water upon it; and so he returned to the method of successive corrosions, by works gradually advancing from opposite banks, and was successful.

In December, 1823, a royal ordinance formed two syndicates of the owners of Coussan and Thivras, with power to make 2180 yards of defensive works each. The lines of wiers were inclined 65° to 75°, to the down-stream shore, and formed of pine piles driven 1·4 yards apart; they were wattled and cut $2\frac{1}{2}$ ft. above low water; they were $54\frac{1}{2}$ yards apart and jutted into river 27 to 33 yards from bank. Each line was connected with a shore line cut 3 ft. above low water. The head of the up-stream side was to be $5\frac{1}{2}$ yards in rear of lines coming from banks, and to project $5\frac{1}{2}$ yards beyond the head of the next lower, thus presenting a salient acute angle and a re-entering acute angle, whose purpose was "to retard the velocity, which, a line having the same curve as stream, would tend to increase and to bring destruction upon the enclosure." In building, this plan was changed so as to present a salient obtuse angle, its apex being 5·4 to 11 yards beyond the middle of a straight line connecting the two heads of lines from banks, or *connecting* lines. But the effect of this was to produce eddies, deposits, and injury to navigation. The willow branches filling voids of wicker-work, rose $1\frac{1}{2}$ yards above low water in the connecting lines, and 2·2 yards in shore lines; there was but little enrockment for the piles, at the foot of which were grounded fascines not even filled with sand, and rising no higher than 3 ft. below surface of low water.



The ice-breaking of 1829 carried away these works, and the pro-

prietors, having to bear one-half the expense, were discouraged; of the \$4927 charged to the Coussan syndicate, but \$3797 were collected. The expense at Thivras was \$3644. These were the principal works of the first period.

Works of the Second Period.—In March, 1828, M. de Baudre presented to the government his beautiful project for the complete restoration of the banks of the Garonne, and it was approved in September. Its successful execution, nearly without change, excites the admiration of all who pass through the valley.

For all the more or less inclined connecting lines, rising $2\frac{1}{2}$ ft. above low water, he substituted throughout lines, normal to the new projected shore lines, rising 5 ft. above low water; for the irregular lines of enclosure and the salient and re-entering angles of Thivras and Coussan, he substituted two regular and nearly parallel lines from 590 to 656 ft. apart, so arranged as to contain the mean water, and with alignments and gentle curves, as near as possible to the channel, and designed to displace the least amount of gravel. His project, so different from any of the previous ones, comprised the development of the river in the two departments of the Lot-et-Garonne and the Gironde; but we have only to deal with that between the mouth of the Lot and the department of Gironde. In this extent of 31 miles, M. de Baudre thought that only where the expense was great the work should be done in concert with proprietors, and that otherwise they should be left entirely to the charge of proprietors.

He designed 15 partial projects with a development of 17·9 miles upon the right bank and 18·2 miles upon the left; the cost of the first establishment, irrespective of plantations and their maintenance, rose to \$411,974, upon which he had counted for \$181,492 to be contributed by proprietors in consideration of the benefits accruing to them, both in defences and in creation of new land.

With these conditions they were to enjoy possession of the alluvions, planting and maintaining at their own cost when delivered over to them by the state. As usual in such cases, it was only the intelligent and rational few who took an interest. But a new impulse was given, and no proprietor undertook aught outside of the proposed line, and the state granted aid to the works already made.

M. de Vivens executed one of these, the 16th in the order of classification of M. de Baudre; it had a development of 3 miles; the expense was estimated at \$36,406, two-thirds of which was to be furnished by the state. He incurred the risk of all damage from high water, and engaged to maintain in good order all parts of the newly formed banks. All the works were completed in 1834. The enrockments were to have been 3 ft. below low water and at some points even with it; but generally they were carried from 3 to 6 ft. above it, and the greatest care was had for their maintenance.

We pass by the various other records of works of the second and third periods, some by the state, some by the proprietors, and some conjointly, whose object was, generally, to suppress secondary arms, to re-unite islands with the shore, to deepen shallows, and protect valu-

able lands; the improvements made for nearly 30 miles cannot be denied, even by those engineers opposed to the system, who think that they can be but partially realized, and at the expense of localities above and below them, having no faith in their durability.

System actually adopted.—It has been said that the lines are nearly parallel, from 574 to 590 ft. apart, except in sharp curves, where they may be 656 ft.; that they are connected with the banks by normal lines at distances from 262 to 328 ft., but which may be 130 to 160 ft. in violent currents. These connecting lines are simple or double; when the velocity is small, two or three single lines are substituted for the double lines, which generally alternate regularly with each other.

The height of shore lines has been constantly on the increase; in the first period, it was 3 ft.; in 1836, it was 6 ft.; in 1842, 8 ft. was adopted. This height is essential for a prompt formation of land, for in 1848 the works of 1836, cut at 6 ft., are, in this respect, far behind the works of 1844, cut at 8 ft. The connecting lines should be higher than shore lines—they are generally $1\frac{1}{2}$ ft. higher—at first they were cut at the same level, except where secured to banks; there the plane of cutting was inclined a length of 16 to 33 ft., so that the last piles secured to bank were at its level.

These lines are formed of pine piles, 7 to 9 ins. thick, spaced $4\frac{1}{2}$ ft., and driven with a hand rope pile driver $6\frac{1}{2}$ to 8 ft. in the gravel; these piles are woven with willow, pine, or oak branches, forming a wicker-work, which is pressed down as low as possible, and always at least 3 ft. below low water mark. In the shore lines the heads of the piles are connected externally by a brace 5 to 6 ins. square, spiked level with their top or 8 ins. below; it protects wicker-work and unites piles.

The connecting lines are made of two parallel lines 3 to 5·3 ft. apart, with cross pieces spiked level, or a little below tops of piles; the space between is filled with gravel, and to prevent loss from undermining, one or several layers of fascines 8 to 10 ins. thick are put in the bottom, and the sides are interlaced with small willow branches. The end towards shore line is usually lined with rubble, sometimes a layer is put on top, and nearly always the surface of this coffer is covered with plantations of willow.

To consolidate shore lines, they are protected externally with rubble to 3 ft. below low water, with a slope of 45°. To economize rubble, which costs 96 cts. per cubic yard, a core is made of fascines, formed of willow or poplar branches filled with gravel, where the depths are over $6\frac{1}{2}$ ft., and this is covered with rubble 5 to $6\frac{1}{2}$ ft. thick. The interior of shore lines and the connecting lines are only consolidated with fascines raised 1·6 ft. below low water; for they are always covered with earth formations before time alters or destroys them.

It is sometimes necessary to consolidate the connecting lines at their establishment in the bank, by covering its upper portion with rubble immediately below the junction; this necessity is felt at the head of the works, especially when the connecting lines are unusually produced; when they project 160 ft. it is indispensable to cover the bank

immediately below the first four or five connecting lines, for a length successively diminished, which may be 16 ft. for the fifth, but should be 98 ft. at least for the first. As far as possible, the shore line should accord with the bank, and in case it is impossible, the end of the first connecting line, or the head of shore line, should be connected with the bank above by an inclined line.

To reduce the velocity of currents which pass above the piles, and to facilitate the deposit of sand and slime, the voids of the wicker-work are as closely packed as possible with willow branches, whose bottom reaches low water, and whose tops rise 13 to 16 ft. above it; in this unfavorable position they frequently thrive a year or two; this operation which hastens the earth formations is called "flocage."

The first winter generally yields a deposit 16 to 33 ft. below connecting lines, and the planting should be made as soon as there is a thickness of 15 to 20 ins. of sand; if the silt has but little consistency 2 to 2½ ft. is needed. In four years nearly the whole of the surface to be subdued may be planted.

Openings 6½ ft. wide are generally left in river lines, for the entrance of lighters, in which the plantings are made; but these should be closed when not in use, as they would allow entering and issuing currents, which retard the deposits, for the more the velocity is slackened the more rapid is their growth.

The closing up of secondary arms formed at the Isles of Cordès, Balias, Souilhagon, and Col-de-Fer, was generally effected by a prolongation of the single shore lines at the head and foot of the isles; but when these shore lines became true dams, as was frequently the case, they were made double, with enrockments exterior and interior, raised to height of cross pieces, and covered on top with rubble. The earth formations were usually so rapid as to do away with the necessity of intermediate dams, and only at Isle Souilhagon was a new dam made midway across, 14 ft. above low water, for checking the violence of high water.

It was thought best at first to leave openings both up and down stream, to facilitate the entrance of currents and gravel, but the upstream openings were soon closed and the precaution was unnecessary. The lower openings were indispensable, for the outlet of such water as might find its way in these arms. The land formations first appear in front and rear of suppressed arms, and care must be taken not to plant immediately upon their whole extent; for then the banks would quickly form to a height of 13 to 16 ft. above low water, leaving the interior in the state of a marsh or pool. A space 60 ft. wide, both above and below, should be left free of all spontaneous growth, as it is the only way to prevent a too sudden uplifting of deposit.

When the shore line passes directly against a bank, or in the rear of it, piles are dispensed with, it being sufficient to excavate the bank a slope of 3 to 1, and covering it with rubble, with willow shoots at intervals; when the deposits have reached 13 ft. above low water, a tow-path may be constructed 50 to 60 ft. in rear of shore line, with a breadth of 13 to 16 ft. and a height of 16 to 18 ft.

Pile-Driving.—The curves are laid out very simply by stretching a cord between two piles, marking of its versed sine, or sagitta, then connecting this point with the ends and taking for sagitta $\frac{1}{4}$ of the first, and so on. The pile-driver is worked by 15 to 25 men, is mounted on a boat, and has a monkey weighing 330 to 660 lbs.; from 10 to 30 may be driven $6\frac{1}{2}$ to 8 ft. in gravel, generally at a cost of 33 to 37 cts. per pile.

In a thin bed of gravel, or only in a bottom of tuffa, an artificial bed is made of fascines $2\frac{1}{2}$ ft. diameter, 13 ft. long; the piles driven in these beds will resist ordinary currents until they are wattled and consolidated with rubble. At first they were all shoed, but experience shows that they enter the hardest gravel as easily if the ends are simply sharpened. Shoes are only indispensable where but a slight bedding in tuffa is desired. There are three kinds of piles: the first, 23 ft. long 9 ins. thick, costing \$3·91 per cubic yard; the second, $19\frac{1}{2}$ to 23 ft. long 7 ins. thick, at \$3·27 per cubic yard; the third, $19\frac{1}{2}$ ft. long 7 ins. thick, at \$2·77 per cubic yard, stripped of bark and delivered on the spot.

Wicker-Work.—The waling rods, of willow, pine, or oak, are generally stripped of the small branches, or they may be wound round the main stem; the large end of a branch is let into the folded shoots of the other; they cross at every $6\frac{1}{2}$ ft. and are bound at crossing by 4 withes. In all cases the big end is placed towards interior of shore lines and turned up stream; in connecting lines it is placed in the interior of the double lines and turned towards the bank. The hurdles and piles are interlaced like weaving, the piles the woof, the waling rods the warp; this is driven down as far as possible by several men jumping forcibly upon it. The wicker-work thus made costs $2\frac{1}{3}$ cents per square yard.

The willow wicker-work is made from the two first choices spoken of; also those of oak and pine are divided into two classes: the first, $16\frac{1}{2}$ ft. long 2 ins. thick; the second, $14\frac{1}{2}$ to $16\frac{1}{2}$ ft. and $1\frac{1}{2}$ ins. thick. Here is a table of number of laths required for 109 square yards of wattling.

	First choice.	Second choice.	Total.
Oak, . .	380	500	880
Pine, .	650	850	1500
Willow, . .	500	750	1250

\$18·60 a thousand is paid for first choice of oak or pine, and \$11·16 for second choice.

Trials made of oak dating six years back, though in exposed positions, show them to be in good condition, while willow lasts but three to four years and pine four to five years; so that oak is now exclusively used for shore lines.

The space between the piles is filled with plantings, packed close as possible within wicker-work; it is termed "flocage," and is gene-

rally composed per running metre of 15 waling rods of willow third choice and 30 of the fourth with all their branches; in no case should their lower extremities be above low water; their height above top of piles should be at least 5 ft. They are protected against towing lines by pieces united to piles, which project every fourth pile 5 to $6\frac{1}{2}$ ft.

The "floeage" of connecting lines is the most useful; they produce their effects in one year, so that plantings upon the alluvium may then take their place. In strong currents they are usually dispensed with in shore lines.

Enrockments.—For economizing rubble, fascines $2\frac{1}{2}$ ft. diameter and 13 ft. long are most generally used upon shore lines; 37 to 43 cts. is usually paid per yard of gravel packed in fascines, in each of which there are eight fagots, made from trimmings of the state plantations and costing from \$2·79 to \$3·72; they are strongly bound at every foot with osier withes; 30 for each, costing \$2·23 the thousand. A gang of four men make from 8 to 10 per day.

The small fascines are 10 ft. long 12 to $15\frac{1}{2}$ ins. thick, and are used in rear of shore lines and below connecting lines; they cost \$4·65 per one hundred, for fashioning, transportation, and sinking. In this quantity are 150 fagots of green, or 200 of dry wood, and they are bound with ten withes.

Outside of the shore lines these fascines are covered with rubble 3 ft. above low water and resist all currents. When the alluvium shall reach a height of 17 ft. above low water at 33 ft. in rear of shore lines, their slope should have 3 to 5 ft. base to 1 ft. height, and covered with a simple layer of rubble to avoid maintenance of wicker-work, which would be impossible when the piles are rotted.

Plantations and Questions of Titles.—The plantings are made, except at the inlet and outlet of secondary arms, as soon as the deposit has consistency for the growth of shoots, and quite often deposits covered by 6 to 10 ft. of water are planted, in preference to the lands lying above it; for though they do not prosper, yet they induce more rapid deposits. The plantings are often torn up or buried in gravel, and have generally to be renewed. Behind connecting and shore lines, and in the interior of inclosures, ribbons of saplings 5 to 6 ft. wide are planted close to each other, perpendicular to shore lines, solely to check the current and promote deposits.

For the preservation of the plantings between tow-path and shore lines, which are of vital importance to the works, the use of oxen and chains are forbid in the ascending navigation; the minimum height above the boats for attachment of lines is 10 ft., and they are to be fastened to the largest boat at head of convoy, six horses being allowed for each.

But for the towing interests, every two years between Nov. 1st and Dec. 31st, cuttings are ordered to be made on their borders.

The question naturally arises as to how much of bed of river belongs to the public, and as to the ownership of property created by the state works.

The proprietors, by no means eager to contribute towards the ex-

pense of these works, were still eager to enjoy the benefits resulting from them, and beside their hopes they brought their hatchets and bill hooks to the cutting of woods designed for the protection of the bank, under the pretext that all belonged to them as far as low water.

The administration put these two questions:—1st. How far does the water extend which forms the essentially variable limit between the bed of the river, or public domain, and private property? Is it low, mean, or high water, just before freshets begin, that should be taken for this limit? 2d. What is the competent authority to determine this limit?

A judgment of the tribunal de Nerac declares, in the absence of special legislation on this point, recourse must be had to the Roman law, where the bank is called that which incloses the river at its greatest height of water. "Ripa ea putatur esse, quæ plenissimum flumen continet." The power to determine this limit evidently belongs to the administration, who alone is charged with the preservation of rivers and all that regards the free running of streams.

In this case, an order of the Prefect prescribed a height of 5 metres on the Marmande scale as the limits in which the exclusive care of the engineers shall be given to the preservation and execution of all works necessary for the increase or consolidation of deposits designed to form new banks of river; whenever the bank surpasses that height it shall become private property.

Some such law was requisite to secure effectual and orderly methods of work. Experience in the commencement of the work had shown the danger of leaving these plantings to be made by the proprietors only.

The other works upon the Garonne relate to the maintenance of the tow-path, dredging of channel, and removal of rocks from bed of river.

The works of the tow-path consist of maintaining earth works at a height of 18 ft. above low water; the slopes are generally planted with willow, sometimes lined with fagots, and rarely with enrockments. They are often shifted, for, not being planted, the surface yielding to the trampling of horses' feet and hollowed out by currents, forms a ditch; in which case, the land adjoining, which has been raised by plantations, is used, and the old path is planted, and in the course of three or four years is ready to take its place.

Ten road-laborers, two navigation overseers, and a superintendent were specially charged with these works.

The bridges, wherever the tow-path is not over from 30 to 80 ft. from the rectified shore line, are generally made of oak with 15 ft. span; when not liable to a change of position they are made of beton of strong hydraulic mortar without any stone.

For trenches with small streams, earthen pipes 14 ins. diameter 1 in. thick, made at Toulouse and delivered at Marmande at $1·67 per running yard, are used. It is well to lay the two heads in enrockment to prevent rupture of extreme tubes.

The rocks are worked with great iron chisels, 14¾ ft. long and 4 ins. diameter, with steel edges, which are driven into the hard tuffa to de-

tach the fragments; they are worked with a pile driver mounted on boats. The front of the bank is cut away perpendicular to the required depth of excavation; the advance is up-stream, detaching portions $1\frac{1}{2}$ ft. wide, allowing them to fall in the undermined parts; the smallest blocks are left to be carried away by the great freshets; the larger are taken out with claws; the excavation costs from \$1·13 to \$1·42 per cubic yard. In this way a channel was excavated across the Reculey rocks, 98 ft. wide 656 ft. long, where there is now a depth of 3 ft. at low water.

The complement of the works of rectification and the endykement of the mean water-bed would be the general endykement of the plain, or limitation of the larger bed, by means of two insubmersible earth levees, with sluices for introducing silt; it was thought that the minimum width between dykes should be 1968 feet, allowing small dykes in the interval, not over a yard high.

From a detail of expenses, there were used for each running yard of shore directly protected, 5·4 cubic yards of rubble, 0·517 cubic yards of pine, 5·3 lbs. of wrought or cast iron. The greatest expense was for enrockment, which came to \$3·52 per yard; then the furnishing and use of piles, which came to \$2·38. The wicker-work and interior planting (flocage), with their renewal till complete, cost \$1·32; and about \$1·70 was expended in fascines, filling of coffers, repairs of waste, and sundries. As a mean, \$1·91 was expended for 119 square yards of plantation.

The advantages gained by these works to the proprietors were, 1st, the defence of the wooded banks; 2d, the creation of new lands; 3d, the security with which insubmersible dykes could be raised at a certain distance from banks.

The advantages to navigation were, in the regulation of the unequal slopes of surface, especially in low water; in the diminution of excessive velocities, which could not be passed without additional horses, and that without sensibly increasing the mean velocity.

The gravel banks or shallows, which always exist in rivers with shifting bottoms, were lowered, so that the minimum draft, which formerly at these passes was but $2\frac{1}{2}$ ft., had attained a depth of 3·6 ft. wherever the works had produced their normal effect; the displaced gravel not obstructing or raising the bed of the river in the lower parts, but deposited in a stable manner, continuous with the banks, whose works have reduced excessive velocities in all stages of water: a unity of direction was imparted to the strongest currents, even until the time of freshets, and beyond these limits there was a power of controlling them with co-ordinate insubmersible levees.

Finally, wherever the bottom was assailable the works have produced a fall in the plane of low water, which fall compensates for the rise in the plane of ordinary freshets, which might be occasioned by the works, and so the fears manifested as to the greater frequency of freshets from contractions of the river, were groundless.

For the Journal of the Franklin Institute.

Bridge over the Theiss, and Tubular Foundations. By M. CEZANNE, Engineer des Ponts et Chaussées. Translated by J. BENNETT.

(Continued from page 14.)

PART THIRD.

Tubular Piers.—The general arrangement of a pier with two cylindrical columns and two square bodies is caused for the Theiss bridge by the necessities of construction, as shown by the drawings; but the choice of materials for the columns, their diameter, their distance apart, their setting up, the height of the separate pieces, the thickness of their sides, the arrangement of the joints, the interior filling, the external defences and modes of execution, are subjects which we propose to describe generally, and in the order specified.

Choice of Materials.—Cast iron was preferred to wrought iron for the cylindrical columns, because they were supposed to be less exposed to heat, and easier managed; still it had its inconveniences: at the bridge of Macon a cast iron column was broken by the shock of a boat; a cold snap in contracting the column upon the interior mass of masonry might cleave the metal. This inconvenience was avoided by forming the part of the column above the summer level in wrought iron segments, riveted to each other by means of exterior angle-irons, so that a broken or rusted segment might be replaced. Wrought iron was adopted for the square bodies, because it was better adapted than cast iron to the square forms and to the connexions with the arches.

Diameter of Tubes.—By increasing the diameter of the columns, the pressure upon the base would be diminished; but the volume of filling would be increased, and the difficulties of manufacture, and especially the sinking of the columns.

An attempt was made to procure at Szegedin the cylindrical drums in one piece, and the diameter of 9·84 ft. was chosen as the greatest made till that time, and because these pieces were to come from Scotland a special provision must be made for their transportation.

With these dimensions, the pressure uniformly spread upon the base was 104 pounds per square inch under the proof trial.

This pressure was raised to 199 pounds for that of the tubes of the Quarantaine bridge at Lyons, which bore the two middle girders.

The English have sunk columns of a greater diameter than 9·84 ft. The barrels were formed of segments bolted to each other.

Below 6·56 feet, the work of the miner was difficult for want of space.

Distance apart of the two adjoining Columns.—3·28 feet was the least distance adopted between the two columns of the same pier, after a consultation with the English engineer having a personal experience of tubular foundations, and, during the construction, it was a matter of regret that a greater distance had not been chosen. A displacement of one column has occurred dnring the operations upon the adjoining one.

The Setting of the Columns.—In the sinking of the columns, re-

gard was had rather to the possible underminings than to the nature of the soil, which continued the same for a great depth. A mean sinking of 19·68 ft. would have been sufficient; a greater depth was adopted for security, and they were usually stopped at about 65·6 ft. below high water, so that they should not be exposed to a pressure of three atmospheres, beyond which the work was very painful to the men.

Height of Barrels.—The height of a column being determined, it remained to decide upon that of the different barrels.

It was for the interest of the work to increase the height to lessen the number of joints; but the founder and transportation agent insisted upon manageable dimensions; 5·95 ft. was adopted.

These drums weigh 12,100 pounds. They were obliged to appropriate for their transportation between Scotland and Germany a special steamboat, and to establish at the point of their arrival at Harbourg, on the Elbe, some fixtures for their removal.

Thickness of the Cylindrical Sides.—When the cast iron columns are only exposed to vertical pressures, calculation indicates that a slight thickness only is needed for the support of the entire bridge; but the founders refused to cast pieces of a thickness too small for the diameter. For this reason, at the bridge over the Great Pee-Dee in America, the engineer was led to the adoption of 1·96 ins. thickness for tubes of 5·97 feet diameter, answering to a resistance 650 times greater than was required.

For the Theiss bridge, it was admitted to be difficult to make regularly tubes of 9·84 ft. diameter with a less thickness than 1·18 ins.

Moreover, it was admitted from experiments made in England at the Viaduct of Tarascon, that cast iron might be subjected to a permanent transverse load equal to $\frac{1}{6}$th of that of rupture, say 6285 lbs. per square inch, for the castings required in this case.

The thickness 1·37 ins. was calculated in regard to this maximum, by considering the column as supported at its two ends, loaded upon its head with the weight Y, and acted upon transversely at the height of the springing by the difference X between the horizontal thrusts of the arches which it bore.

The dispositions of the final plan furnished the following data, in the most unfavorable case for the stability of the pier, or that in which one of the two adjacent bays is charged with 5365 lbs. per running foot, while the other is free.

We have for a single column: $Y = 367{,}400$ lbs.
$X = 360{,}800$ "

a, the distance between the point of application of the force X and the head of the column, where the top stringers of the arches are made fast to the column, equal to 18·93 ft.

b, the remainder of the height of the column to the head of the interior piles, equal to 65·37 ft.

R,	the work relative to X per square inch,			5657 lbs.	
Q,	"	"	Y	"	728 "
R + Q,	"	"	compression,		6385 "
R — Q,	"	"	tension,		4929 "

The value R — Q is the maximum of efforts of tension produced by the trial loads; it is much less in practice since the usual loads over the road are much below that of the trial proof; because only one track is loaded at a time, and the struttings of the arches and the connexions with the square bodies tend to distribute between the two tubes the reactions of the arches.

In the conditions of the contract the proportions of the castings were not determined, but it was required that bars of prescribed dimensions should be cast at each tapping and subjected to direct experiments.

Experiments were made in this way upon 442 bars in breaking them by a transverse loading,—they had a section of 1·57 ins. by 1·3 ins.; their mean resistance was 30 k. 4 per square millimetre or 43,428 lbs. per square inch.

The maximum was 52,285 lbs.; the minimum, 29,000 lbs., occasioned by a fault in the casting at the point of fracture.

The resistance required by the contract was 37,143 lbs.

Upon the testing of the bridge, the most unfavorable case for the stability of the piers was chosen by loading each span with 5365 lbs. per running foot, all the other spans being free, and the following laws were observed.

All the piers deflected at the level of the springing lines in separating from the loaded span.

The two piers next the loaded span as a mean deflected 0·157 in.; the two piers at the distance of one span deflected 0·059 in.; these deflections diminished rapidly with their distance from the loaded span; they were sensible, though they could not be measured from one extremity to the other of the bridge.

The depressions at the summit of the spans, which were but 0·472 in. when all the bridge was loaded, attained 1·18 ins. for the single loaded span, which is explained by the increase of the cord; the two adjacent spans rose from 0·196 to 0·236 in.; the following to ·078 in. at most; further on no motion was detected.

The usual locomotive trains were passed over the two tracks with great speed, either side by side, or in opposite directions: this trial did not give any maximum for the deflections of the trusses or that of the piers.

Arrangement of the Joints.—The method of jointage is shown in Pl. I., Fig. 3, where we see the bearing or turned surface upon which the two barrels are brought in contact, the jointing which prevents their sliding, the bands or flanches which receive the one the head, the other the nut, of a bolt, which fastens them, and the ribs or brackets which unite the flanch with the cylindrical part. A tight joint is made by iron filings cement tamped with a graver between the two flanches. The ribs are badly contrived, at least under the flanch, which at the foundry is placed at the upper part of the mould; they form there recesses in which the gas bubbles lodge, thus producing blisters. It would be advisable to suppress the ribs, to increase the thickness of the flanches, and the radius of the roundings of the jointage.

The cement was composed as follows:—

Iron filings,	1000	parts in weight.
Sal almoniac,	10	"
Flowers of sulphur,	2	"
Water for dissolving the salt.		

This mixture would set in two days during the summer, in eight days during the winter; it was then worked with the file and smoothed, but became impaired in moist air.

For the iron filings cement, was substituted at the bridge of Bordeaux an india-rubber cord let into a groove, simplifying the joint, and economizing in time and manœuvring.

The two adjoining flanches of the Theiss bridge were fastened by 48 bolts, 1·97 ins. diameter, which would be much too strong were these columns but to bear the simple weight of the bridge, and these bolts designed but to fasten the joint; whereas, these columns had to resist transverse thrusts, and accordingly it became necessary to fortify the joints as much as possible. The most exposed, that of the square body with the cast iron capital, was secured with 72 bolts.

Calculation applied to the joints of the circular barrels, gives for the maximum load per square inch of strain of bolt 6528 lbs., or even 16,025 lbs., according as we suppose the neutral axis to be at the centre of the circular joint, or at the circumference.*

We should reduce the number of bolts to the strict necessity of the case, to simplify the jointage, and to facilitate the tamping of the mortar, and 8, 12, or 16 bolts of 1·18 ins. will generally be sufficient.

Interior Filling.—The beton serves to give mass to the columns, and to distribute their weight upon the entire base. Usually it bears the platform directly; in that case, the metallic covering is a sort of coffer dam. At the Theiss bridge, the columns with other duties to fulfil, have their solidity with the beton insured by the following arrangements:—

The square wrought iron body surmounting the cast iron column, and upon which the arches abut, is strengthened within by two strong girders, PP, of double T iron (Pl. I., Fig. 2), which connect the two opposite faces, and sustain them against the thrust of the arches.

Beneath these girders is a brick and cut stone masonry, which crowns the beton and bears the large iron wedges driven forcibly under the girders. This square body receives and transmits to the cast iron column the weight of the superstructure and its loads; and it cannot sink without bearing with it the interior girders, the masonry, and the beton.

The beton being perfectly contained in its metallic envelope, its quality is not a matter of importance.

It is said that a bridge has been constructed in America whose columns are filled with sand. If we go to the expense of beton, it is naturally desirable that it should set; now, some observations seem

* The neutral axis is in reality between these two positions; it may be found by a rigorous calculation, but we are led into transcendental equations, whose solution is laborious.

to prove that the setting of the beton in the tubular columns does not depend solely upon the quality of the beton itself.

When, with a view of rebuilding the column at Macon, which, as we have said before, was broken by a boat, it was found in demolishing it that the beton, quite hard at the upper part, became more and more soft as the bottom was approached. At the Theiss bridge, the lower barrel of a column of the first pier had been broken by the interior piling; after repairing it, it was proposed to fill this and the barrel above it with a mass of Portland cement, in which the head of the piles might rest, so that the foot of the column in case of loss of broken drum, might be none the less firmly established.

After having laid carefully many cubic yards of cement mortar at the bottom of the column, it was found that the setting was far from being as rapid as that in open air, and if the work was stopped a few hours, the lower parts became filled with water, which could clearly be seen to be disengaged from the mortar itself.

This observation and that at Macon induced the belief that one of the conditions of the setting of hydraulic mortars is that they should absorb the water, so as to retain the quantity exacted by the chemical reaction of solidification. This condition is far from being fulfilled in the tubular piers, which are air-tight, and it is possible that the most hydraulic betons may never set in them. An attempt was made to avoid this evil by mixing with the beton a certain quantity of fragments of dry bricks; it was thought that these porous materials might drain the mass of its excess of water. This possibly hazardous theory seemed, however, to be confirmed by the following experiment: the first pier of the bridge, founded in detestable earth, occasioned uneasiness from the commencement of the work. The down-stream column was the first constructed; it was loaded with 580,800 lbs. of rails for the trial proof; it sunk 1·53 ins. The up-stream column, whose foot was broken, and where brick was introduced in the beton, was proved in the same manner, and only sunk 0·18 in. This result could not be attributed to the cement mortar, which did not occupy the sixth of the total height of the interrupted masonry.*

The beton of the columns is generally commenced with a plugging in cement from two to three feet thick, for the purpose of closing the bottom of the column against the entrance of water occasioned by a momentary stopping of the air-pump, and by a diminution of the pressure. This precaution was not necessary at Szegedin, where it was determined in the execution of the work to sustain the foot of the columns by an interior piling, which by pressing the foundation rendered it perfectly staunch.

This piling (Pl. I., Fig. 2) is composed for each column of twelve spruce piles driven to a refusal of 5·9 ins. for 10 blows of a 2200 lbs. ram, falling 19·68 ft. It is admitted that each of these piles may bear about 50 tons each. The whole load to be borne with that of the trial proof was 1,144,000 lbs.†

At the general proof of the bridge, the sinking observed upon the

* See note B, upon a machine for making beton. † See in note C some remarks upon piling.

piers was from ·08 to ·12 in. The two columns of the first pier already proved, each sunk ·12 inch more. All the columns supported the test weight for twenty-four hours; some during thirty-six hours: frequent observations were made upon them, and it was remarked that after twelve hours of loading the sinking had nearly stopped.

External Defences.—The piers of the Theiss bridge were protected against undermining by a circuit of piles, a mass of beton, and by enrockments, for the purpose of strengthening the foot of the piers, and for diminishing the leverage of the transverse thrusts of the arches.

The breaking up of ice and the drifting boats are kept clear of the pier by a timber ice breaker, presenting to the current an inclined edge strengthened with iron, and spreading towards the pier so as to cover its whole width without resting upon it.

Modes of Execution.—The barrels of the Theiss bridge were cast in Glasgow, and brought in a rough state to Szegedin; they were turned and pierced in the workshop of the bridge.

The lathe was formed of a horizontal platform, upon which was placed the barrel, accurately centred and turning with it. Two tools fixed in a mass of masonry and provided with the means of adjustment, planed the two surfaces at the same time.

From twelve to fifteen hours were required to prepare a tube.

The drilling was done with the usual machinery; two drills, working simultaneously, pierced 96 holes in 30 hours, including the time of fitting up.

It was only after a trial made of two consecutive tubes placed on each other, that they were carried to the scaffolding of the pier.

These scaffolds were composed of five frames, spaced 13·12 feet apart. There was then in the inner gallery of the scaffolds four compartments of 13·12 ft. by 16·4 ft.; two for the columns, and two, one on the up-stream, the other on the down-stream side, serving as depots; the side galleries formed by the inclined braces afforded passage to and fro. The service bridge was connected with the up-stream compartment; upon the crown of the scaffold, one or two windlasses were worked upon a car.

These scaffolds had the serious inconvenience of not affording sufficient room around the columns, and of yielding too easily to the inclinations of their guides.

The landing of a column upon the bottom of the river was an interesting operation. There were two processes. When the water was shallow and the scaffolds high, the column was constructed upon a temporary platform placed as low as possible; then, being seized at the head by the windlasses, it was allowed to descend. When the water was deep and the scaffolds failing in height, which was the case at Szegedin, the operation was two-fold; a first part of the column was lowered and hung upon long iron hooks, whose heads were raised above the water and fastened to the scaffold. Upon this base, nearly all submerged, was raised the remainder of the column, which was then lowered entire.

A wrought iron cross-bar with three branches took hold of the upper flanch of the top barrel through six bolt holes. This was suspended to a wrought iron beam which balanced the action of the two windlasses.

The column weighs 66,000 lbs.; there are eight men at each windlass; each block has 4 sheeves and a fall of 1·97 inches.

The second process consists of fitting a wooden bottom to the lower barrel, and in floating the column; it is well in this case to reserve the means of moderating, and, at need, of stopping, the entrance of the water, so as to have full control of the column during its establishment.

A column weighing 30 tons thus placed upon the bottom of the river, never sinks more than a few centimetres (cent. = 0·39 in.) if the soil is of gravel or compact clay; though in a bottom of sand and mud some of the columns have sunk 3·28 ft.

Before placing the pneumatic fixtures upon the column, care is taken to instal upon the flanches of the upper joint, that separating the first drum from the second (Pl. I., Fig. 4), a flooring, a windlass and its chain, some pieces of wood, shovels, picks, &c., and generally all t hematerials whose dimensions do not admit of being passed through the air chamber: at the same time, the water syphon tube is located by being attached to the different flanches.

Pneumatic Bell. (Pl. I., Fig. 4.)—The pneumatic receiver is a cylindrical drum of rolled iron of the same diameter as the cast iron column, open at the bottom, and closed on top by a flooring or roof. The lower circular edge is provided with an angle-iron pierced with holes corresponding with those of the upper flanch of the column. A strip of india-rubber being placed between the receiver and the column, all that is needed for the joint is, to bolt strongly the flanch and the angle-iron.

The roof of the receiver is traversed by two bodies, M M, nearly cylindrical, of cast iron, in a vertical direction, having about two-thirds of their height within the receiver, and the remainder jutting beyond it.

These two similar and independent cylinders form each an air chamber, which may be closed at the top by a circular valve opening inwards, and turning upon a horizontal hinge; and at the bottom, by a vertical rectangular door, cutting the cylindrical body parallel to its edges, opening round a vertical hinge from the interior of the chamber towards the interior of the column. The door and valve are lined with strips of india-rubber. Different pipes and cocks, D, allow communication between the interior of the air chamber with the exterior of the reservoir or with the atmosphere; these tubes are manœuvred either by men placed under the receiver upon the interior flooring, or by those placed under the air chamber, or by those on the outside.

The remaining apparatus consists of two valve fixtures, to which are applied two air tubes, communicating with the pumps by a safety valve, a metallic manometer (Bourdon's), two other valves affording a rapid escape of the interior pressure, a bend of a syphon, with a cock

upon the inside. All these contrivances are fitted to the cylindrical sides of the reservoir, which also supports a series of brackets, upon which are placed the cast iron counterweights.

These counterweights are of cast iron segments, whose form is adapted to the contours and projections of the bell. They are united to each other in pieces of 11,000 lbs. weight. With some modifications in the form of the brackets, the ordinary rails may be used.

The air and syphon tubes are of iron, and have on one side a collar, and on the other a wormed mouth-piece (Pl. I., Figs. 5 and 6). The collar of the one pipe enters the mouth-piece of the other, and the latter turns independently of the pipe which bears it, so that the joints can be tightened without dismounting the pipe. Some india-rubber joints give a pliability to the system needed to follow the motions of the boats and those of the columns.

(To be Continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

Description of Aerts' Water Axle-box. By Mr. Sampson Lloyd.

From Newton's London Journal, April, 1861.

The attention of engineers and carriage builders has been constantly directed to improvements in railway axle-boxes, as shown by the various contrivances that have been invented for the purpose. These, however, have all included the use of oleaginous matter as a lubricator, though it is well known there is an inherent defect attached to such a material, since the brass bearing must be heated, by the friction of the journal, before the grease can be brought down to lubricate the bearing. If a perfect lubricator for railway axles could be obtained, it would effect a great saving both of tractive power and also of commercial cost, as compared with a material that performs its duty in an imperfect manner. The essential conditions for a good method of lubrication are,—first, a constant and abundant supply of a pure lubricating fluid; and, secondly, the working parts should be always kept free from foreign substances, the tendency of which is to increase the friction, or to intercept the free contact of the lubricating material with the bearing surfaces. These conditions are successfully fulfilled in the simple construction of axle-box now about to be described, which is the invention of M. Aerts of Belgium,—the principal feature being the use of water as the lubricator, in place of oil or grease which has generally been used on railways, thus avoiding the many inconveniences that have resulted from the use of fatty substances.

On the end of the axle a cast iron disc is firmly fixed, working in a reservoir of water. When the carriage moves, the disc, turning round with the axle, raises the water by the centrifugal force of its rotation into the upper part of the axle-box, where it is caught by a brass scraper, resting loosely on the top of the disc, and is discharged

into the inclined spout, which conducts it directly over the axle, and thus lubricates the bearing completely and continuously. The lubrication thus commences as soon as the carriage is put in motion, and the quantity of water lubricating the bearing is increased in proportion to the velocity of rotation, since the faster the disc turns, the greater is the quantity of water carried up with it.

The joint at the back of the axle-box is made by a cast iron collar, keyed on the axle immediately behind the journal; it is turned accurately on the outside, and runs within a leather collar that is made to be just a fit upon it; this leather collar is riveted inside an annular cast iron disc, and is kept always close upon the collar by the slight pressure of a small india-rubber band or steel spring surrounding it. To prevent leakage of water between the leather and the cast iron collar, where the friction takes place in the running, the flanch of the collar is made of a conical form, and the inner side of the annular disc is similarly shaped, so that, by the rotation of the collar, the water is thrown away from the joint by centrifugal force, and returned into the axle-box. The disc is held up against the back of the axle-box by an outside back plate, and has a thick india-rubber ring let into a groove in its face, which presses against the back of the axle-box and forms a water-tight joint; allowing for the box coming down as the brass wears, and at the same time affording sufficient elasticity to admit of a slight play of the disc within the space at the back of the box whilst running. When the axle-boxes are well fitted, and the joint at the back properly made, there is no leakage of water, and the level of the water does not perceptibly vary during a long time of running, since that which has lubricated the axle returns into the reservoir in the lower part of the box; and the amount of evaporation of the water is in practice so small as to be scarcely appreciable.

With the ordinary method of lubrication, if an axle gets heated, it is cooled by throwing water on it; but in the water axle-box, the water, being poured over the axle in a continuous stream, effectually prevents it from heating. Water has also the advantage of allowing all solid particles to sink to the bottom of the reservoir; but where grease is used, these remain mixed with it, and thus become the chief source of wear and heating of the bearing. To clean the reservoir, it is only necessary to unscrew a plug in the lower part of the box, which allows the dirty water to run out; and by means of a syringe, such as is used in cleaning the carriages, the reservoir can be thoroughly rinsed through; the screw is then replaced, and a supply of fresh water poured into the box through the lid. This process is, therefore, neither difficult nor expensive in the water axle-box; while with the ordinary grease box, when it gets out of order, the carriage must be raised and the bolts of the box unfastened, which requires considerable time and the attendance of several workmen. If the reservoir should accidentally be omitted to be filled with water, or if, by any means, the water should run out of the box, there is still an ordinary grease box as a reserve to fall back upon, which will come into use on an emergency, the upper part of the box containing a

supply of grease like an ordinary axle-box; but as the waste of water is so very small, such a case is not likely to occur when proper care is exercised.

When applying this method of lubrication by water to the bearings of shafting, the disc for raising the water, as the shaft revolves, is made in two halves, fastened together by lugs, and fixed on the shaft by a set screw or key; the water carried up is caught by a scraper, which discharges it direct upon the top of the bearing.

Before fixing the water axle-boxes in place, the brass bearing and axle are both well greased, so as to prevent oxidation of the metal by the water; while the water prevents the contact of the two metals as it passes between the two greased surfaces. In practice, the grease is found to solidify after a short time of running, and forms a sort of varnish of a dark brown color, thus proving the absence of actual contact between the two metal surfaces; for were it otherwise, the surface of the axle would become polished.

This water axle-box was tried on the Great Northern Railway during the early part of the year 1860, on a second class carriage having two of the bearings fitted with the water box and two with the ordinary grease box used on that line. The result of five weeks running over a total distance of 9819 miles was, that the brass bearings of the water axle-boxes were not found to be diminished in weight, while the bearings of the grease boxes had lost together 4½ ounces; and the water boxes ran 7326 miles without requiring to be replenished with water. Trials of the water axle-boxes have also been made on the Eastern Counties Railway during the past and present years: the two bearings of one axle in a first-class carriage of an express train were fitted with the water axle-boxes, and those of the other axle with the ordinary grease boxes; after running a total distance of 11,249 miles during two months constant working, the brasses in the ordinary boxes had lost together 30 ounces in weight, while those in the water boxes had lost together only 7 ounces, or less than one-fourth; the wear of the brasses occurring principally at the shoulders of the bearings. The consumption of grease in this trial was 8½ lbs. in the two ordinary axle-boxes, and in the water boxes 3 lbs., which, however, was all consumed on one journey and in one box, in consequence of the box having been, by neglect, allowed to run without water on one occasion; but no inconvenience was occasioned, as the tallow in the reserve grease chamber was quite sufficient to lubricate the bearing in the absence of the water. In a subsequent trial on another first-class carriage, during two months constant running, the water axle-boxes worked remarkably well; they ran for many days a distance of 252 miles daily, without requiring additional water, and were not supplied with any grease after that originally put in.

By this method of using so simple and perfect a lubricating material as water, the cost of oil or grease is saved, and it is calculated that a considerable saving of traction results from the almost total absence of friction, while the wear of the brasses and journals is reduced to a minimum; so that instead of the brasses lasting on the

average only nine months, as is ordinarily the case, their time of running is greatly increased.

Mr. Lloyd showed a specimen of the water axle-box for railway carriages, and a model of its application to bearings of shafting. He had brought the subject forward because his experience of the axle-box had been very satisfactory, as regarded its application both to railway bearings and to shafting revolving at a rapid rate; and improvement in lubrication was of great importance, particularly for the axles of railway carriages, where the present cost of grease and renewal of brasses formed such a large item of expense. At Mr. Leech's mill at Staleybridge, where the water boxes had been applied, there was a large shaft that previously caused great difficulty by heating, and required oiling two or three times during the day; but by applying the water boxes, the shaft had now been running more than a year, without any heating taking place, and no trouble had been experienced with the bearings; they continued working quite satisfactorily, the grease having formed a varnish over the bearing surfaces.

Mr. Aerts explained, that the principle of lubrication by means of water was not a new one, it having been previously used for stationary bearings in mills, as in the case of the bearings of rolls; but in such instances, the water was employed in a current running over the bearing to keep it cool, and was all allowed to run away.

He further said, it was desirable to allow a slight leakage of water at the leather collar where the friction took place, in order to insure the leather being kept always moist. It was possible to run 1000 miles without any fresh supply of water to the box; but in practice it was advisable to replenish the boxes with water every day, or after running 400 or 500 miles. For emptying the water quickly out of the axle-box, the hole at the bottom of the box was now closed by an india-rubber washer, held up by a spring instead of by a screwed plug; this saved time and trouble, and avoided the use of tools. The handle of the spring came up in front of the box, and had a slot in it, so as to be readily fixed open for the water to run out, or closed securely when a fresh supply had been poured in.—*Proc. Mech. Eng. Soc.*, Aug. 9th, 1860.

Experiments to Determine the Properties of some Mixtures of Cast Iron and Nickel. By William Fairbairn, F. R. S.

From the Lond. Chemical News, No. 52.

Some of my chemical friends in London had got an impression, from a careful analysis of meteoric iron, that it could be produced artificially by the combination of some of the same elements that were found to exist in the specimen analyzed, containing about $2\frac{1}{2}$ per cent. of nickel.

In order to determine whether it would be possible to obtain an artificial compound of this nature, and to ascertain the effect produced

by mixing a certain proportion of nickel with cast iron, the following experiments were instituted. They consisted, in the first instance, in the extraction of the nickel from the ore which is found in the mines of the Duke of Argyle, near Inverary, in Scotland. The metal having then been purified by repeated meltings, was mixed with cast iron in such proportions as to form a compound, containing the same quantity of nickel as the specimen analyzed. This was done by melting $2\frac{1}{2}$ per cent. of nickel with carefully selected South Welsh cast iron from the works of Blaenavon and Pontypool. The mixtures were fused in crucibles, and run into ingots or bars, which were then tested in regard to their mechanical powers of resistance to a transverse strain.

This was done with great care, and the results which follow give unmistakeable evidence of the effects produced upon cast iron by an admixture of nickel, however small the quantity of the latter that may be introduced. Meteoric iron is, above all others, the most ductile, and it is recorded by travelers that the Esquimaux have instruments made from this description of iron so ductile that they may be made to bend round the arm. The ingots prepared on the occasion of these experiments were, however, widely different, as their power to resist impact was nearly one-half less than in those composed of pure iron.

It is uncertain what might have been the results had the castings produced been treated as cast steel, and hammered out until they were rendered malleable and magnetic. This process was not, however, attempted, as, judging from the appearance of the fracture, they were more likely to crumble under the hammer than attain malleability.

The nickel for these experiments was prepared from the ore, by fusing at a very high temperature in a crucible or steel pot,

30 lbs. of roasted ore,
5 " fine sand,
2 " charcoal,
2 " lime.

This mixture was kept in the furnace six hours, and then taken out and allowed to cool. The metal was then separated from the slag, and again melted with half its weight of roasted ore and one quarter its weight of green bottle glass ground to powder.

As before, the mixture was kept for six hours, at the temperature of a cast steel furnace. The metal had by the end of that time collected at the bottom of the crucible. It contained about 25 per cent. of nickel, and was of sufficient purity to be fused with cast iron. 10 lbs. of it melted with 112 lbs. of cast iron gave a mixture containing about $2\frac{1}{2}$ per cent. of nickel.

The object of these fusings was to reduce the metallic oxide by means of the charcoal, while the lime and sand removed the oxide of iron, silica, sulphur, and other impurities by forming a fusible slag.

Mixtures of nickel with cast iron (No. 1) and Blaenavon iron (No. 3) and Pontypool iron, each containing about $2\frac{1}{2}$ per cent. of nickel,

and also some pure Blaenavon cast iron (No. 1), were cast into bars about one inch square, and two feet six inches long, and subjected to the following experimental tests.

(A table showing the breaking weight and deflections of the bars when subjected to a transverse strain is here given in the original. Want of space obliges us to omit it. The results reduced from it are given in the following table.)

TABLE I.—*Results reduced to bars 1″ square. Distance between the supports 2′ 3″.*

	Breaking weight (b).	Ultimate deflection (d).	Power of resisting impact ($b \times d$).	Strength compared with Blaenavon = 1000.
Experiment I. Bar D, pure Blaenavon No. 3, ...	1131	0·75	848·2	1000
Experiment II. Bar C, Blaenavon No. 3 and nickel, . . .	875	0·58	507·5	773
Experiment III. Bar B, pure cast iron No. 1, ...	861	0·47	404·7	761
Experiment IV. Bar A, cast iron No. 1 and nickel, ...	637	0·434	276·4	563
Experiment V. Bar E, Pontypool iron and pure nickel, . . .	798	0·366	292·1	705
Mean, . .	860	0·52	465·7	760

From the above, it is evident that an admixture of nickel in the proportion of $2\frac{1}{2}$ per cent. does not increase, but diminish, the tenacity of cast iron. To what extent it might be improved by augmenting or lessening the proportion of nickel, a more extended series of experiments alone can determine. Mixtures of the two metals in the proportion used in the above experiments are decidedly inferior to the pure metal in their power of resistance to a transverse strain and to impact. In the first and second experiments on Blaenavon iron there is a loss of nearly one-fifth the strength; or the strength of the pure metal is to that of the mixture as 1000 : 773. And in experiments III. and IV., with a more fluid iron there is about the same loss, the relative strengths being as 761 : 563; or as 1000 : 740. From these facts, it is evident that nickel in the proportion of $2\frac{1}{2}$ per cent. seriously injures the strength of cast iron, and, moreover, has injurious effects on its power of resisting impact, as the columns in the above table indicating those properties clearly show.

It is difficult to account for the serious deterioration and loss of strength which the above experiments indicate. It may probably arise from the improper treatment of the nickel ore during its calcination and subsequent reduction in the crucible. When cast into ingots after the second melting, the nickel had not the appearance of a pure metal, but exhibited a dull fracture, as if fine sand or particles of earth had been mixed with the crystals, showing the presence of

impurities which it would be almost impossible to get rid of. It remained, therefore, a question for consideration whether the results would be different if nickel, properly prepared and of greater purity, were employed. To clear up doubts on this point, a mixture of pure nickel with No. 3 Pontypool iron was made, but the result was a bar of white silvery metal, which broke when the weight of 798 lbs. was laid on, as will be seen by reference to the tables above.

I obtained from London a number of other bars, consisting of iron and nickel, which, on being submitted to the same tests as before, gave better results than those obtained in the previous experiments when nickel prepared from the ore was employed.

The results obtained from this second series of bars are given in the following table:—*

Table II.—*Results reduced to bars 1″×1″. Distance between the supports 2′ 3″.*

	Breaking weight (*b*).	Ultimate deflection (*d*).	Power of resisting impact (*b*×*d*).	Rates of strength Bar F 2 = 1000.
Experiment VI. Bar F 1 without notches, . . .	867	0·315	273	1000 : 876
Experiment VII. Bar F 2 without notches, . . .	989	0 38	376	1000 : 1000
Experiment VIII. Bar G 1 with one notch, ...	760	0·331	231	1000 : 768
Experiment IX. Bar G 2 with one notch, ...	899	0·41	368	1000 : 908
Experiment X. Bar H 1 with two notches, . . .	746	0 286	213	1000 : 754
Experiment XI. Bar H 2 with two notches, . . .	703	0·29	203	1000 : 810
Mean, . .	829	0·335	280	1000 : 838

I have been unable to ascertain the precise composition of these bars: but, assuming it to have been similar to that of the first series of bars, the greater powers of resistance shown by them would seem to indicate that the nickel employed in their preparation possessed a higher degree of purity than that used for the first series. Much, however, depends on the quality of the cast iron with which the nickel is mixed. The results derived from the foregoing experiments are conclusive, both in regard to those made on the first and those made on the second series of bars. Further experiments may, however, lead to different results; but, judging from what has already been done, I am inclined to believe that chemical combinations of a different nature are required, and probably a totally different process of manufacture will have to be adopted before a sufficiently strong and satisfactory compound can be obtained.

* The table is omitted as before, the results alone being contained in the table given.

In attempting to ascertain the effect of a mixture of nickel with cast iron, the principal object was to determine to what extent the compound gave positive or negative results. It is well known that meteoric iron is peculiarly ductile, and it was assumed that nickel, added to cast iron in such proportion as to produce a compound similar to meteoric iron, would impart to it increased ductility. The foregoing experiments lead, however, to the conclusion that an admixture of nickel, produces an exactly opposite effect, and it now remains to be determined, by a more extended series of experiments, whether by mixing nickel with malleable iron in the same relative proportion more satisfactory results would be obtained. In prosecuting these experiments, it would be interesting to know the extent to which these metals are capable of combining chemically, how closely such combinations would approximate to meteoric iron.

Besides endeavoring to obtain a metal of greater ductility, another object of equal importance was aimed at in these experiments, namely, to produce a metal of increased tenacity suitable for the casting of cannon and heavy ordnance. During the last two years, innumerable experiments have been made for this purpose, with more or less success; but the ultimate result appears to be, that for the construction of heavy artillery there is no metal so well calculated to resist the explosion of gunpowder, as a perfectly homogeneous mass of the best and purest cast iron, when freed from sulphur and phosphorus.—*Memoirs of the Literary and Philosophical Society of Manchester*, vol. xv.

Nomenclature of Printed-Stuffs.

M. Chevreul read to the French Academy of Sciences a memoir on the distinctions which would give the most perfect security to commerce as to the stability of the colors on stuffs, without interfering with the freedom of business. In place of the vague and useless distinctions now adopted, he proposes the following: *very stable*, *stable*, *moderately-stable*, *changeable;* expressed in numbers, or in the degrees of the chromatic scale which the prints lose after one, six, or twelve months exposure to the light and air. There is but one very stable color, that is, *indigo* applied by M. Chevreul's process, by passing through steam. *Indigo* applied by the old process is merely stable: *Cochineal* and *Madder* with certain mordants are stable; with other mordants they are only *moderately-stable*, as is *Weld* (*reseda-luteola*). *Brazil* and *Campeachy-woods* are moderately-stable. *Annotta* (*bixa orellana*), *Turmeric*, and *Safflower* are changeable.

M. Chevreul regrets that certain new colors, such as *muroxide*, *orcëine*, *fuchsine*, *azalëine*, which are very beautiful and agreeable to the eye at first, but very changeable, should have been over-praised of late, at the expense of the old and stable colors, indigo, cochineal, weld, which will remain alone or nearly alone in the manufactories when their rivals have disappeared.

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Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 46.)

Hollow Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.—Low Moor Iron, No. 2.

Length or height in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated breaking weight in tons from formulæ, $b = 46{\cdot}65 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	24	5	4	127·84	31·96	12·78
"	20	6	5	189·36	47·34	18 93
"	17 1-7	7	5½	359·07	89 76	35 90
"	15	8	6½	463·84	115·96	46·38
"	13 1-3	9	7½	574·13	143·53	57·41
"	12	10	8½	687·32	171·83	68 73
"	10 10-11	11	9	1033·95	258·48	103·39
"	10	12	10	1190 64	297 66	119 06
"	9 3-13	13	11	1349·25	337·31	131·92
"	8 4-7	14	12	1508·89	377·22	150·88
"	8	15	12½	2037·59	509·39	203·75
"	7 1-2	16	13½	2239 80	559 95	223 98
"	7 1-17	17	14½	2436 66	609·16	243·66
"	6 2-3	18	15½	2641·49	660·37	264·14

Table showing the Breaking Weight of Solid Uniform Cylindrical Pillars for different qualities of Cast Iron, Both Ends being Flat and Firmly Fixed, and the Safe Weight of same if Irregularly Fixed.

Height of pillar in ft.	Diameter in inches.	*For the Breaking Weight if Firmly Fixed.* Co-efficients for the strength in lbs., 78,400	89,600	100,800	112,000	123,200	134,400
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
8	2	11·95	13 66	15·36	17·07	18·78	20·49
10	2	8·17	9·34	10·51	11·68	12·85	14 02
10	3	34·50	39·43	44·35	49·28	54·21	59 14
12½	3	23·61	26·98	30·35	33·72	37·10	40·47
12½	4	65·56	74·92	84·29	93·65	103·02	112·38
15	4	48·08	54·95	61·82	68 69	75 56	82·43
15½	5	100·42	114·76	129·11	143·45	157·80	172·15
17	5	85 82	98·09	110 35	122 61	134·87	147·13
17½	6	156·07	178·37	200·66	222·96	245·26	267 55
20	6	124·37	142·14	159·91	177·68	195·45	213·22
		For the Safe Weight if Irregularly Fixed.					
8	2	1·19	1·36	1·53	1·70	1·87	2·04
10	2	0·81	0·93	1·05	1·16	1·28	1·40
10	3	3·45	3·94	4·43	4·92	5·42	5·91
12½	3	2·36	2·69	3·03	3·37	3·71	4·04
12½	4	6 55	7·49	8·42	9·36	10·30	11·23
15	4	4·80	5·49	6·18	6 86	7·55	8·24
15½	5	10·04	11·47	12·91	14·34	15·78	17·21
17	5	8·58	9·80	11·03	12·26	13·48	14·71
17½	6	15·60	17 83	20·06	22·29	24·52	26·75
20	6	12·43	14·21	15·99	17·76	19·54	21·32

In Mr. Hodgkinson's edition of Tredgold's Practical Essay on the Strength of Cast Iron, &c., page 26, a table is there given, entitled "A Table to show the weight or pressure a cylindrical pillar or column of cast iron will sustain, with safety, in hundredweights." This table was calculated by the following formula:—

$l =$ length in feet, $d =$ diameter in inches, $w =$ weight to be supported in lbs.,

$$\frac{9562\,d^4}{4\,d^2 + \cdot 18\,l^2} = w\,.$$

The following table is an abstract from Mr. Tredgold's, with this difference: the original is given in hundredweights, and I have reduced it to tons. A note attached to this table by Mr. Hodgkinson, says: "This table has no solid basis. The very ingenious reasoning from which the formula is deduced by which the table was calculated, depends upon assumptions which Mr. Tredgold was induced to adopt through want of experimental data. See Mr. Barlow's Report on the Strength of Materials, 2d vol., of the British Association."

Table from Tredgold, reduced to Tons.

Diameter in inches.	Length or height,							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
2	3·00	2·45	2·00	1·60	1·30	1·10	0·90	0·75
2½	5·25	4·55	3·85	3·25	2·75	2·35	2·00	1·70
3	8·15	7·25	6·40	5·55	4·85	4·20	3·65	3·20
3½	11·60	10·70	9·55	8·60	7·80	6·75	5·95	5·30
4	15·50	14·40	13·30	12·10	11·00	9·90	8·90	8·00
4½	20·00	18·95	17·70	16·35	15·05	13·75	12·55	11·45
5	25·05	23·95	22·60	21·35	19·70	18·25	16·85	15·50
6	29·60	28·65	27·50	26·25	24·85	23·45	22·00	20·65

Table from my calculations, being One-Twelfth of the Breaking Weight as deduced from Mr. Hodgkinson's formulæ for Solid Pillars of Cast Iron with Flat Ends.

Diameter in inches.	Length or height,							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
2	2·04	1·25	0·85	0·63	0·48	0·38	0·31	0·26
2½	4·52	2·77	1·89	1·39	1·07	0·85	0·69	0·58
3	8·23	5·30	3·62	2·66	2·04	1·63	1·33	1·11
3½	13·21	9·16	6·27	4·59	3·53	2·82	2·30	1·92
4	19·71	14·19	10·07	7·38	5·68	4·53	3·70	3·10
4½	27·80	20·43	15·30	11·22	8·63	6·88	5·63	4·70
5	37·56	28·13	21·64	16·31	12·55	10·00	8·18	6·84
6	62·23	48·21	38·00	30·55	23·98	19·11	15·64	13·07

Table from my calculations, being One-Fourth of the Breaking Weight as deduced from Mr. Hodgkinson's formula for Solid Pillars of Cast Iron with Rounded Ends, and from calculations based on other of Mr. H.'s formulæ.

Diameter in inches.	Length or height,							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
2	2·39	1·47	1·00	0·73	0·56	0·45	0·37	0·30
2½	5·42	3·40	2·32	1·70	1·31	1·04	0·85	0·71
3	9·82	6·75	4·62	3·39	2·60	2·07	1·70	1·42
3½	15·75	11·45	8·25	6·05	4·66	3·71	3·04	2·54
4	23·62	17·58	13·47	10·00	7·69	6·13	5·02	4·19
4½	33·30	25·39	19·79	15·58	11·98	9·55	7·82	6·53
5	44·86	34·99	27·71	22·36	17·81	14·19	11·62	9·71
6	73·63	59·70	48·71	40·19	33·59	28·18	23·05	19·28

Table from my calculations, being One-Twelfth of the Breaking Weight as deduced from Mr. Hodgkinson's formulæ for Solid Pillars of Wrought Iron with Flat Ends.

2	3·62	2·03	1·30	0·90	0·66	0·50	0·40	0·32
2½	6·96	4·50	2·88	2·00	1·47	1·12	0·88	0·72
3	11·95	8·20	5·50	3·82	2·80	2·15	1·69	1·37
3½	18·57	13·17	9·51	6·60	4·85	3·71	2·93	2·37
4	26·92	19·65	14·59	10·61	7·80	5·97	4·71	3·82
4½	37·00	27·72	20·96	16·13	11·85	9·07	7·16	5·80
5	48·85	37·46	28·83	22·49	17·22	13·18	10·42	8·44
6	77·83	62·09	49·28	39·35	31·79	25·19	19·90	16·12

Table from my calculations, being One-Fourth of the Breaking Weight as deduced from Mr. Hodgkinson's formula for Solid Pillars of Wrought Iron with Rounded Ends, and from calculations based on other of Mr. H.'s formulæ.

2	4·02	2·26	1·44	1·00	0·64	0·50	0·40	0·36
2½	8·39	5·23	3·34	2·32	1·70	1·30	1·03	0·83
3	14·86	10·11	6·65	4·62	3·39	2·60	2·05	1·66
3½	23·61	16·66	11·88	8·25	6·06	4·64	3·66	2·97
4	34·75	25·33	18·78	13·63	10·01	7·67	6·06	4·90
4½	48·30	36·27	27·43	21·23	15·60	11·94	9·43	7·64
5	64·27	49·55	38·28	29·95	23·18	17·75	14·02	11·36
6	103·39	83·28	66·69	53·61	43·52	35·23	27·84	22·55

Mr. Hodgkinson gives the following formulæ for the breaking weight of solid cylindrical pillars, both ends being rounded, and the length of the pillars exceeding 15 times their diameters:

For cast iron, $$W = 14{\cdot}9 \frac{D^{3.76}}{L^{1.7}}.$$

For wrought iron, $$W = 42{\cdot}8 \frac{D^{3.76}}{L^{2}}.$$

In the following tables for cast iron pillars with rounded ends, and in succeeding tables for wrought iron pillars with rounded ends, it will be seen how far I have made use of Mr. Hodgkinson's formula, withholding for the present the formulæ I have used for those pillars below 30 diameters.

Tables showing the calculated breaking weight and safe weight of uniform solid cylindrical pillars of cast iron, both ends being rounded or irregularly fixed.

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9 \frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Safe weight in tons.
5	30	2	13·05		3·26
6	36	"		9·59	2 39
7	42	"		7 38	1·84
8	48	"		5·88	1·47
9	54	"		4·81	1·20
10	60	"		4 02	1·00
11	66	"		3·42	0 85
12	72	"		2·95	0·73
13	78	"		2 57	0·64
14	84	"		2·27	0 56
15	90	"		2·02	0 50
16	96	"		1·81	0·45
17	102	"		1·63	0·40
18	108	"		1·48	0 37
19	114	"		1·35	0·33
20	120	"		1·23	0 30
5	24	2½	26·93		6·73
6	28 8	"	21·70		5·42
7	33·6	"		17·06	4·26
8	38·4	"		13·60	3 40
9	43 2	"		11·13	2·78
10	48	"		9·30	2·32
11	52·8	"		7·91	1·97
12	57·6	"		6·82	1·70
13	62 4	"		5·95	1·48
14	67·2	"		5·25	1·31
15	72	"		4·67	1·16
16	76·8	"		4·18	1·04
17	81·6	"		3·77	0 94
18	86·4	"		3·42	0·85
19	91·2	"		3·12	0·78
20	96	"		2·86	0·71

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9 \frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Safe weight in tons.
5	20	3	47·53		11·88
6	24	"	39·29		9·82
7	28	"	32·60		8·15
8	32	"		27·03	6·75
9	36	"		22·12	5·53
10	40	"		18·49	4·62
11	44	"		15·73	3·93
12	48	"		13·56	3·39
13	52	"		11·84	2·96
14	56	"		10·43	2·60
15	60	"		9·28	2·32
16	64	"		8·31	2·07
17	68	"		7·50	1·87
18	72	"		6·81	1·70
19	76	"		6·21	1·55
20	80	"		5·69	1·42
5	17·142	$3\frac{1}{2}$	75·32		18·83
6	20·571	"	63·00		15·75
7	24	"	53·56		13·39
8	27·428	"	45·81		11·45
9	30·857	"		39·50	9·87
10	34·285	"		33·02	8·25
11	37·714	"		28·08	7·02
12	41·142	"		24·22	6·05
13	44·571	"		21·14	5·28
14	48	"		18·64	4·66
15	51·428	"		16·57	4·14
16	54·857	"		14·85	3·71
17	58·284	"		13·40	3·35
18	61·714	"		12·16	3·04
19	65·142	"		11·09	2·77
20	68·571	"		10·16	2·54
5	15	4	110·57		27·64
6	18	"	94·50		23·62
7	21	"	81·23		20·30
8	24	"	70·32		17·58
9	27	"	61·32		15·33
10	30	"	53·88		13·47
11	33	"		46·40	11·60
12	36	"		40·02	10·00
13	39	"		34·93	8·73
14	42	"		30·79	7·69
15	45	"		27·38	6·84
16	48	"		24·54	6·13
17	51	"		22·13	5·53
18	54	"		20·08	5·02
19	57	"		18·32	4·58
20	60	"		16·79	4·19

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 14 \cdot 9 \frac{D^{3 \cdot 76}}{L^{1 \cdot 7}}$.	Safe weight in tons.
5	13 333	$4\frac{1}{2}$	153·57		38·34
6	16	"	133·20		33 30
7	18·666	"	116·05		29·01
8	21·333	"	101·58		25 39
9	24	"	89 08		22·27
10	26·666	"	79·17		19·79
11	29·333	"	70·50		17 62
12	32	"		62·32	15 58
13	34·666	"		54·39	13 59
14	37·333	"		47 95	11 98
15	40	"		42·64	10·66
16	42·666	"		38·21	9 55
17	45·333	"		34·47	8·61
18	48	"		31 28	7·82
19	50·666	"		28·53	7·13
20	53·333	"		26·15	6 53
5	12	5	203 72		50·93
6	14·4	"	179 44		44 86
7	16·8	"	158 24		39·56
8	19·2	"	139 96		34·99
9	21·6	"	124·28		31·07
10	24	"	110·86		27·71
11	26·4	"	99·35		24·83
12	28·8	"	89·46		22·36
13	31·2	"		80·83	20 20
14	33·6	"		71·26	17·81
15	36	"		63·38	15·84
16	38·4	"		56·79	14·19
17	40·8	"		51·23	12·80
18	43·2	"		46·48	11·62
19	45·6	"		42·40	10·60
20	48	"		38·86	9·71
5	10	6	326·77		81·69
6	12	"	294 55		73 63
7	14	"	265·17		66·29
8	16	"	238·83		59·70
9	18	"	215 47		53·86
10	20	"	194 86		48·71
11	22	"	176·74		44·18
12	24	"	160·79		40·19
13	26	"	147·03		36·75
14	28	"	134·38		33·59
15	30	"	123·44		30·86
16	32	"		112·72	28·18
17	34	"		101·68	25·42
18	36	"		92·20	23·05
19	38	"		84·16	21·04
20	40	"		77·13	19·28

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44 \cdot 34 \frac{D^{3 \cdot 55} - d^{3 \cdot 55}}{L^{1 \cdot 7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4} c}$.	Safe weight in tons.
8	9 3-5	10	$8\frac{1}{2}$	545·46		764 06	191·01
9	10 4-5	"	"	613 64		718 68	179 67
10	12	"	"	681 83		675·32	168 83
11	13 1-5	"	"	750·01		634·29	158 57
12	14 2-5	"	"	818 19		595 70	148 92
13	15 3 5	"	"	886 37		559·62	139·90
14	16 4-5	"	"	954 56		525·98	131·49
15	18	"	"	1022 74		494 73	123·68
16	19 1-5	"	"	1090·92		465·73	116·43
17	20 2-5	"	"	1159·11		438·85	109·71
18	21 3-5	"	"	1227·29		413 98	103 49
19	22 4-5	"	"	1295·47		390·92	97·73
20	24	"	"	1363 66		369 56	92·39
21	25 1-5	"	"	1431 84		349 78	87·44
22	26 2-5	"	"	1500 02		331·43	82 85
23	27 3-5	"	"	1568 20		314·41	78 60
24	28 4-5	"	"	1636·39		298 60	74·65
25	30	"	"	1704 57		283·90	70 97
26	31 1-5	"	"	1772·75		270·22	67·55
27	32 2-5	"	"	1840 94	254·44		63 61
28	33 3-5	"	"	1909·12	239·18		59·79
29	34 4-5	"	"	1977·30	225·32		56·33
30	36	"	"	2045·49	212·70		53·17
8	8 8-11	11	$9\frac{1}{2}$	604·43		883 38	220·84
9	9 9-11	"	"	679 98		836·33	209 08
10	10 10-11	"	"	755·54		790 80	197·70
11	12	"	"	831·09		747·17	186·79
12	13 1-11	"	"	906·64		705 67	176 41
13	14 2-11	"	"	982 20		666·44	166·61
14	15 3-11	"	"	1057·75		629·50	157 37
15	16 4-11	"	"	1133·31		594·84	148·71
16	17 5-11	"	"	1208 86		562·39	140·59
17	18 6-11	"	"	1284·41		532 06	133·01
18	19 7-11	"	"	1359·97		503·77	125·94
19	20 8-11	"	"	1435·52		477 36	119 34
20	21 9-11	"	"	1511 08		452 74	113·18
21	22 10-11	"	"	1586·63		429·79	107·44
22	24	"	"	1662 18		408·38	102·09
23	25 1-11	"	"	1737·74		388·41	97 10
24	26 2-11	"	"	1813 29		369·77	92 44
25	27 3-11	"	"	1888 85		352·36	88 09
26	28 4-11	"	"	1964·40		336·09	84·02
27	29 5-11	"	"	2039·95		320·86	80·21
28	30 6-11	"	"	2115·51		306·60	76·65
29	31 7-11	"	"	2191·06	292·36		73·09
30	32 8-11	"	"	2266·62	275·98		68 99

(To be Continued.)

On the Application of the Decimal System of Measurement in Boring and Turning Wheels and Axles. By Mr. John Fernie, of Derby.

From Newton's London Journal, June, 1861.

In a former paper, the writer stated some of the advantages to be derived from the application of the decimal system of measurement to various descriptions of mechanical engineering work, amongst which was the securing of wheels on their axles. In ordinary railway practice, the wheels are pressed on the axles by the hydraulic press, the wheel boss being bored so much smaller than the axle, that a certain amount of tension is put on the boss, such as experience may have shown to be safe. But this amount has always been empirical, and vaguely designated as a bare 16th, or a full 32d of an inch; and nothing could more forcibly show the necessity of a new system, than the measurement of the actual dimensions of the gauges hitherto in use, in which it has been found that the degree of tightness, or the difference in diameter between the wheel boss and the axle, ranged from ·003 to ·012 inch. The writer's object has, therefore, been to fix standard sizes for boring and turning, so that uniformity may be attained; and with this view, a number of trials were made.

The first step was to make two gauges, one 6·000 inches, and the other 5·988 inches long: to the larger of these an axle was carefully turned, and to the smaller, a wheel carefully bored; the difference of diameter being thus, ·012 inch: the wheel was then pressed on the axle, and again pressed off. There was considerable difficulty in pressing it off; three men, on a long lever, putting on a pressure of at least 80 tons; and it was only after some violent blows of a sledge-hammer that the wheel made the first start: after a few such starts, it came off easily. After being pressed off, the condition of the axle end, as well as of the boss, led to the conclusion, that an excessive strain had been applied, injurious to both wheel and axle; this appeared more fully on measurement. The axle was reduced ·002 inch in diameter, for nearly a third of the length in the wheel, and ·001 inch at the middle of the length, whence it gradually tapered off to its original size; the surface of the axle was also cut, though it had been well oiled before pressing the wheel on. The boss, on a careful measurement, was found to have sustained a permanent stretch, amounting to ·006 inch, and was slightly taper, and also slightly cut like the axle.

It was considered that the degree of tightness required was one that would not inflict any permanent injury on the wheel or axle; and in order to determine the amount, further experiments were made. In the fifth experiment, with a difference in diameter amounting to ·003 inch, and with the wheel very carefully bored and the axle very carefully turned, the wheel was pressed on and off without the boss retaining any permanent stretch, or the axle sustaining any injury. In addition, however, to great care in the boring and turning, it is necessary to get very smooth surfaces; for, in some of the trials made, it was found that when the wheels and axles were turned with a narrow-pointed tool, leaving the surfaces slightly rough, the tops of the sur-

faces or threads were ground off, and they would not stand pressing on or off so well as when they were turned very smoothly. The greatest difficulty in working to such small dimensions consists, not in the want of skill of the workmen, but in the roughness of the present machinery: some lathes have a strong bias to run taper, and some run slightly oval; there may also be some want of uniformity in the nature of the material, hard places to grind away the tool, or to press harder against it, and so make it work taper or oval. For these reasons, although ·003 inch appeared to be sufficient difference in diameter in the best work, the writer was ultimately led to adopt ·005 inch, the result of which is, a small permanent stretch of the wheel boss; but this is compensated for by the contraction of the tyre, which throws a considerable amount of compression on the boss. With ·005 inch difference in diameter, the wheel is pressed easily on the axle with a pressure of about 20 tons; and the permanent stretch, as measured in a number of wheels tried, amounts to from ·001 to ·002 inch. As it is almost impossible to secure a perfectly parallel hole through the boss, the lathe should be so arranged that the largest size is the entering side of the wheel; and if properly managed, a good fit from end to end of the hole may be obtained.

In securing the outside cranks on the axle ends, it has been found by experiment, that, instead of an allowance for shrinkage, amounting to ·030 inch on a diameter of 6 inches, ·015 inch is amply sufficient; and in pressing cross-head spindles of 2·5 inches diameter into their place, a difference in diameter of ·004 inch is sufficient; while levers with 3-inch holes require a difference of ·001 inch, when they are to be driven on with a lead hammer.

From a lengthened experience of this decimal system of measurement, the writer is more than ever satisfied of the importance and practicability of carrying out Mr. Whitworth's excellent system into the workshop: workmen soon learn to work to the fine measurements, and no difficulty has been experienced in this respect. Gauges, such as are used for standard sizes, are made in the ordinary way from standard end measures, by which the gauges in use can be verified, or new ones supplied at any time. For axle turning, the gauges are of steel, of the old horse-shoe shape, and are allowed to drop over the axle by their own weight; for wheel boring, they are made of flat steel, with the ends bluntly rounded over, and are made to pass through the boss with an easy pressure. There is no difficulty in working with these gauges to one-thousandth of an inch. Standard gauges for wheels and axles, levers, and shafts, made by Mr. Whitworth's measuring machine, can be obtained, giving the difference in size, as above described; and these need not go into the workshop, but can be kept for reference, others being made from them for ordinary wear and tear in the turning shop; and thus standard sizes may be got and kept, which will be of great value.

The decimal measuring machine constructed by the writer at the Midland Railway Works, Derby, and employed for producing the various standard gauges for use in the workshops, is similar in principle

and construction to Mr. Whitworth's measuring machine described at a former meeting of the Institution; the principle of its construction being that of end or contact measurement instead of line measurement, depending on the sense of touch instead of sight.

The machine consists of a strong and heavy cast iron bed, long enough to take in a measurement of 100 inches, and having a right-angled V groove in the top surface, in which the gauges to be measured are laid. At either end are adjustable centres. One centre is advanced or drawn back by an adjusting screw and nut, the latter being held stationary in the end of the bed, and turned by a hand-wheel of 10 inches diameter. The adjusting screw is made with, as nearly as practicable, 10 threads per inch, and the circumference of the hand-wheel, which is 2 inches wide, has a spiral line chased upon it, of rather more than ten turns; a standard inch bar is placed in the machine, and adjusted by a gravity piece in the manner afterwards described; and the position of the centre which receives its adjustment from the hand-wheel, is marked by a line against an index on the first turn of the spiral. The standard bar being then removed, the centre is advanced by the screw through the interval of 1 inch left vacant by its removal, and the position again marked by a line on the last turn of the spiral. The spiral is then carefully divided between these two marks into 10 equal parts, each of which is one revolution of the hand-wheel nearly, and corresponds exactly to ·1 or $\frac{1}{10}$th of an inch motion of the centre: each revolution of the spiral is then subdivided between the divisions previously obtained into 100 equal parts, so that each interval on the circumference of the hand-wheel represents accurately ·001 or $\frac{1}{1000}$th of an inch motion of the centre. By this plan the difficulty and expense of obtaining a screw having exactly 10 threads per inch, are obviated in a simple manner; any small excess or deficiency in the pitch of the screw being thrown into the spiral line on the hand-wheel, the correct graduation of which is accurately obtained from one of the standard inch gauges. In order to prevent any play in the nut, through which the screw works, it is made in two lengths, which are set together on the screw. The back centre is merely held tight by friction, by the grip of a wrought iron strap cottered to the bed; so that in case the hand-wheel should be turned round too far, the back centre will give way, and prevent the measuring screw from being injured by a strain: it is fitted with a small screw for the purpose of approximately adjusting the length of the groove in the bed.

For making a duplicate of any standard gauge by the measuring machine, the standard gauge is laid in the groove of the bed, and the distance to the back centre is made up with bars of convenient length. The measuring screw and centre which it operates are then advanced gradually by the hand-wheel, until the gravity piece, on being lifted by the finger at one end, remains suspended between the ends of the standard gauge and centre, the pressure being just sufficient to support its weight; and the corresponding graduation on the hand-wheel having been noted against the index, the centre is slacked back and the standard gauge removed. The proposed duplicate is then placed

in the machine and tried by means of the gravity piece; and its length is very carefully reduced by grinding the ends, with successive trials in the machine, until the gravity piece is again just supported between the duplicate gauge and the centre with the same reading on the hand-wheel as previously; when the length of the duplicate is known to be accurately the same as that of the original standard. The graduation on the hand-wheel affords the means also of producing gauges differing by any required amount from the standard gauges. Thus the gauges previously described, for boring the wheel bosses of 5·995 inches diameter, are made from the standard gauge of 6 inches length, by subtracting five divisions from the reading on the hand-wheel; so that the measuring screw has to be advanced ·005 or $\frac{5}{1000}$ths of an inch further before the gravity piece is held suspended.

The standard gauges used in the machine are steel bars one inch square, with the edges beveled off; the ends are made conical and reduced to a circle of $\frac{1}{4}$-inch diameter. A single 1-inch standard is sufficient for producing by the machine all the longer standards that are required, by making first another 1-inch standard, then a 2-inch standard from these two placed together end to end, and so on in succession; and the machine is long enough for measuring any length up to 100 inches.

Mr. C. W. Siemens said it was highly gratifying to see that such great accuracy had been carried out in work on a large scale as had been explained, and he was confident it would well repay any extra trouble by the superior quality of work obtained and the facility for renewal. Mr. Whitworth had rendered most important service by introducing the system of accurate decimal measurement; but he did not think the inch adopted by him as the unit of measurement was the most eligible, and it might become necessary at a future time to go over the question again in order to adopt a universal standard amongst civilized countries. It was a general opinion of the International Decimal Association that the only chance of getting a universal measure was to adopt the metre, which was convenient for use in this country, being nearly the length of the present yard; while the millimetre was generally the smallest size wanted for the workshop, being $\frac{1}{26}$th of an inch (·039 inch). The metre was now becoming the unit in many tables and calculations, and he regretted that another unit should be established in this country. He doubted whether $\frac{1}{1000}$th of an inch could be worked to in practice, and thought the gauges employed would be affected to that amount by difference in temperature.

Mr. C. Markham observed that the inch had been adopted as the standard, not on account of any intrinsic superiority over the metre, but because it was not practicable to carry out the metre system in this country, and the metre had lately been found to be a scientific fallacy as regarded its supposed perfection as a standard. Mr. Whitworth had adopted the inch as the standard on account of its universal application in the workshops and in all mechanical operations in this country. There did not appear to be any probability of getting the decimal system of measurement into use in this country except by

adopting for the standard the inch already recognised and in general use, so that the introduction of the decimal subdivision involved no change of measure. The improvements that had taken place in the construction of machines, and the remarkable truth and accuracy with which work was now executed, rendered it essential for the progress of mechanical science that $\frac{1}{1000}$th of an inch should be readily appreciated in the workshops by ordinary workmen. The Whitworth and Enfield rifles were bored out to $\frac{1}{1000}$th of an inch, and workmen soon became accustomed to work with extreme accuracy and truth. With the decimal system much greater accuracy was obtained than with ordinary fractions, by employing the sense of touch on Mr. Whitworth's plan of end or contact measurement, by which smaller dimensions than $\frac{1}{1000}$th of an inch were readily appreciated; and, in practice, it was required to have the means of expressing dimensions down to $\frac{1}{1000}$th of an inch, as illustrated by the results given in the paper just read. Different descriptions of wheels required to be bored out with slightly different allowances in the diameters; a solid cast iron wheel requiring to be bored out larger than a wheel with a light boss and spokes; and this difference could be readily measured and worked to by the decimal system with the use of gauges in the manner that had been described.—*Proc. Mech. Eng. Soc.*

On the Value of Different Kinds of Soap. By R. Graeger.

From the Lond. Chemical News, No. 68.

Complaints of consumers in regard to the value, or rather efficacy, of samples of soap, which to the best of the manufacturer's knowledge have been well prepared, are not uncommon.

It is very probable that the usual explanation which is offered, whenever a soap fails to fulfil the expectations of its consumer, viz: that it contains too much water, may be in many cases correct. Admitting this, and various other contingencies, which are of importance in deciding upon the value of a soap, there appears to be another obvious reason why different soaps containing equal amounts of water may still possess different degrees of efficacy.

It is evident from the different equivalent weights of the various fatty acids, that the amounts of caustic alkali taken up by them in the formation of soap must be of unlike magnitude.

If it be true, that the detergent power of soap is entirely dependent upon the amount of alkali which it contains, of course it follows that those soaps which contain the largest proportion of alkali,—or in other words, those containing a fatty acid, the equivalent weight of which is small,—must be the most efficacious.

Since the difference between the equivalents of the common fatty acids is not large, these considerations are, perhaps, of little or no importance in so far as concerns the consumption of soap in household economy—the total amount used in a single family being but small. In a manufacturing establishment, however, where fifty or a hundred

thousand pounds of soap may be used in the course of a year, differences which cannot be deemed insignificant must exhibit themselves.

For example, the equivalent weights of several soaps (regarded as anhydrous), in common use, are as follows:—

Oleic acid (red oil) soap,		= 3800·95
Palm oil	"	= 3588·85
Tallow	"	= 3300·95
Cocoa-nut oil	"	= 3065·45

Calculating from these weights how much of each of the other soaps would be required to replace 1000 pounds of tallow soap, the following quantities will be found:—

1151 lbs.	of oleic acid soap,	*i. e.*,	15·1 per cent.	more	than tallow soap.
1087 "	palm oil "	*i. e.*,	8·7 "		"
928 "	cocoa-nut oil "	*i. e.*,	7·2 "	less	"

Differences like these must certainly be of importance in practice; and could, doubtless, be detected by direct experiment, if any one would undertake a comparison of the various kinds of soap—a research which would not be easy, however.—*Bœttger's Polytechnisches Notizblatt.*

Artesian Well.

The *Cosmos* announces the final success of the artesian well which has been sunk at Passy near Paris for the purpose of furnishing the water for the artificial rivulets of the Bois de Bologne. The bed of water was met at a depth of 577 metres (1893 feet) on Saturday at 4 o'clock, A. M., and on Sunday it had risen to from 6 to 9 feet below the surface. The slowness of its rise is caused by the tube being choked with sand, which, however, is supposed not to come from any caving in of the sides or bottom of the bore.

On Boilers and Boiler Plates. By Mr. Ramsell.

From Newton's London Journal, June, 1861.

The author remarked, primarily, that twenty years experience in the construction of steam boilers had given him some practical knowledge of his subject, and that, therefore, he had little diffidence in speaking upon it. He had long ago become convinced of the necessity of adopting a different principle to that usually acted upon in the manufacture of boilers; and a very important point was to do away with "stays," as used for strengthening them. More especially, he referred to marine boilers, and instanced, in the following order, three principal evils attending the employment of stays: 1st, the obstruction they offered to the effectually cleaning of the boilers; 2d, the increased amount of incrustation induced by them; and, 3d, the water and steam space they occupied. The fracture of the steel boilers of the *John Penn*, S. V., which came especially under his notice last year, prompted him to give more consideration to the subject. In those

boilers, the number of stays rendered necessary by the thinness of the plates, made it almost impossible to clean them out, while the cracking of the plates at the sides of the fire-boxes completed their ruin. The steel boilers were, eventually, and after a very short trial, removed from the *John Penn*, and their places were supplied by iron ones.

Having witnessed this, and many other instances of the evils of stays, Mr. Ramsell stated, that he had come to the conclusion that iron plates for boilers might be so prepared as to give them strength, to a great extent, without adding to their thickness, or much to their weight. This object he proposed to effect by producing corrugations or indentations of any shape in the middle of each plate, and leaving plain surfaces on their outer edges, for the purpose of riveting them together. Plain surfaces for manholes, and the attachment of pipes, would also be left where necessary. The corrugations or indentations might be made by rollers or presses, as found most desirable or applicable to the particular size or shape of the boiler to be made. He had provided and used both rollers and presses for the purpose, and had experimented upon the plates produced by them. One series of experiments he would give them the details of, they having been made in the presence of Mr. Miles, of the firm of Humphrys and Tennant:

Two plates, made from $\frac{3}{8}$-inch bowling iron plate, the centre of the plates being only $\frac{1}{4}$ inch thick. Length and breadth from centre to centre of rivets, 5 feet by 3 feet 4 inches. Surface exposed to pressure, 6 feet 6 inches by 3 feet $5\frac{1}{2}$ inches,—equal to 22 square feet. At a pressure of 20 lbs. per square inch, or equal to 28 tons 5 cwt. 2 qrs. 24 lbs. on the whole surface, it expands in centre of plate $\frac{1}{32}$d of an inch.

		T.	C.	Q.	LBS.			
At 30 lbs.,	or =	42	8	2	8	it expanded	$\frac{1}{16}$	inch.
40	"	56	11	1	20	"	$\frac{3}{32}$	"
50	"	70	14	1	1	"	$\frac{1}{8}$	"
60	"	84	17	0	16	"	$\frac{3}{6}$	"
70	"	99	0	0	0	"	1	"
75	"	106	1	1	24	"	$1\frac{1}{4}$	"

A full $\frac{3}{8}$-inch boiler plate, flat, with a surface of 3 feet 4 inches, by 3 feet $2\frac{1}{2}$ inches, from centre to centre of rivets, expanded in centre of plate as follows:—

At a pressure of	5	lbs. per square inch,	$\frac{3}{32}$	inch.
"	10	"	$\frac{1}{4}$	"
"	15	"	$\frac{5}{16}$	"
"	20	"	$\frac{3}{8}$	"
"	25	"	$\frac{7}{16}$	"
"	30	"	$\frac{1}{2}$	"
"	35	"	$\frac{9}{16}$	"
"	40	"	$\frac{5}{8}$	"

These results demonstrated the superiority of plates manufactured on the corrugated or indented plan. The author did not confine him-

self, in the patent which he had secured, to any particular form of indentation, nor to whether these should project on one or both sides of the plates. He simply maintained that his process imparted additional strength to ordinary plates, whilst it tested severely the quality of the metal, without waiting for the pressure of steam to do it. In one steel plate of the *John Penn*, 10 feet + 2 feet 6 inches + $\frac{3}{16}$-inch thick, 72 stays were employed; in one of his of the same dimensions, 9 such stays only would be necessary. In the back of the boiler of the same vessel, 320 stays had been used, whereas 70 would have given equal stability in the same space in a boiler of his construction.

Other facts of a similar character were mentioned by Mr. Ramsell, who illustrated his paper by drawings and models, which were handed round for the inspection of members. On the conclusion of the paper a discussion arose, Mr. Aydon taking exceptions to some of the statements made, and putting several pertinent and practical questions respecting the originality of the plans propounded. Mr. Stabler, Mr. Owbridge, Mr. Jones, and others, joined in remarks favorable or otherwise to Mr. Ramsell's views, whilst the Chairman admitted that much light had been thrown upon a very important, and, indeed, vital matter, in connexion with steam boilers, and thought that further experiments should be made as to the strength of the plates. Mr. Ramsell met all the objections, and courted further examination at his works at Deptford.—*Proc. Asso. Foremen Eng.*, May 4, 1861.

Novel Arrangement of Steam Boilers.

At the meeting of the Society of Civil Engineers of Vienna, M. Alexander Strecker communicated a very ingenious and simple mode of preventing the burning of steam boilers. This apparatus, invented by M. J. Haswell, director of the Vienna Locomotive Factory, consists in introducing into the interior of the boiler a small turbine, which continually drives the water from the bottom towards the front of the boiler: thus on the one hand cooling the walls which are most liable to overheat, and on the other facilitating the formation of steam. This arrangement, which has been tried with perfect success on a 40-horse-power boiler, has just been adapted to all the stationary boilers in the workshop of the Western Railroad.—*Cosmos.*

On Sulphur in Gas. By Alfred Kitt.

From the Lond. Jour. of Gas Lighting, &c., No. 222.

Sir—I forward you the result of a series of experiments made on coal-gas, which will, perhaps, be of interest to some of your readers. My object in making these experiments was to ascertain the effect of furnace heat, at various temperatures, on the illuminating power of coal-gas—first suggested on reading Mr. Bowditch's correspondence in your Journal.

The apparatus I employed was (for the tube) a piece of 1-inch

tubing, connected at each end with a piece of $\frac{1}{2}$-inch tube, and provided with a stop-cock. The condenser used was of glass, immersed in water; the lime-purifier was made specially for the purpose with a water-seal, and contained exactly two layers of damped cold lime, each of them $3\frac{1}{2}$ inches thick. The gas-holders held 10 cubic feet each, and care was taken to have the water in the tank as clean as possible.

The tube was placed, without any material whatever inside, over the furnace, and 14-candle gas was introduced at one end, under a pressure of $\frac{30}{10}$ths. The tube was so heated as to give a temperature of 300° Fahr. to the gas at its exit from the other end of the tube. The gas, before entering the tube, was tested for sulphur, and was found not in the least to touch the lead-paper, when tested at 300° Fahr. at its exit from the tube; and, again, after passing through the condenser at a temperature of 60° Fahr., the lead paper was immediately darkened by the formation of sulphuret of lead. The gas was passed through the purifier, and perfectly cleansed of the sulphuretted hydrogen generated in the tube before entering the gas-holder. The illuminating power of the gas thus operated on was then carefully taken, when it was found to be reduced to 8·50 candles sperm. Being desirous of ascertaining the further decrease of its illuminating constituents, the same gas of $8\frac{1}{2}$ candles was conducted back again through the tube at the same temperature of 300° Fahr., and condensed, and then tried with the acetate of lead-test as before, which it almost as readily darkened as at first. It was then re-purified, and stored into the other gas-holder kept for the purpose. The illuminating power being then tried for the second time, was found to be 6·75 candles sperm. The same process was repeated for a third time at the same temperature, and the lead-paper applied after condenser as before; the paper on this occasion was merely colored a light brown. After purification, it was again conducted into the gas-holder. The illuminating power was then reduced to 5·75.

The gas was thus deprived of its illuminating constituents in the following order:—

	Candles Sperm.
Illuminating power of gas employed,	14
After 1st trial through tube, gas heated at 300° Fahr., and condensed to 60°,	8·50
" 2d "	6·75
" 3d "	5·75

The illuminating power was taken in the usual manner, with a photometer and a test-metre, and with an Argand burner consuming 5 cubic feet of gas per hour, and a spermaceti candle consuming 120 grains of sperm per hour. The result clearly proves that *heat* decomposes the volatile hydrocarbons existing in coal-gas, and, if the same gas was continued to be thus operated on, it would eventually lose its luminosity. Like experiments were made at lower temperatures, and in every case sulphur was obtained the second, third, and fourth time of trial, and a proportionate decrease in its illuminating power.

Sulphur in gas begins first to pass over and affects the lead-paper

and the solution of lead at a temperature of 110° Fahr., and continues to increase in quantity as the temperature rises. This sulphur, undoubtedly, proceeds principally from the decomposition of the volatile hydrocarbons. When the gas at the exit of tube is of the temperature of 400° to 450° Fahr., it loses just so much of its illuminating power as to reduce it to one-half; and, if the lead-paper is held for one moment in the current of the gas, it is immediately blackened. At high temperatures, the gas should be cooled through a condenser, else the test will be scorched, and will very likely mislead the operator.

In conclusion, I would observe that coal-gas, of the illuminating power of 14 sperm candles, when heated to the temperature of boiling water only, and recondensed and purified to a temperature of 60°, loses fully 20 per cent. of its illuminating quality. I have in all experiments found the like decomposition of the hydrocarbon vapors takes place, whether lime, brick-dust, or any other substance which is not chemically acted on by the agents employed, is placed in the tube.

The above experiments were made at these works, and will show to any gas engineer the impossibility, for all practical purposes, of obtaining gas utterly free from sulphur, by passing it through a heated medium.

Bath, April 15, 1861.

Chandor's Gas-Generator

Consists of a box about 1 foot high and 16 inches square in base, containing some 5 gallons of mineral oil or naphtha; a small fan moved by clock-work, stirs the liquid continually. Under the influence of a current of warm air which can be regulated at will, the mineral oil evaporates and forms a very rich and brilliant lighting-gas, burning without smoke, and in such quantity that it burns steadily at the mouth of a tube of more than an inch in diameter. It is used at present only to furnish a gas-engine, and its cost is said by Mr. Chandor (an American in Paris) not to exceed 7 centimes per cubic metre (39·65 cents per 1000 cubic feet).—*Cosmos.*

On Steam Boiler Explosions.

From the Lond. Mechanics' Magazine, April, 1861.

Mr. L. E. Fletcher, chief engineer, presented his monthly report, from which the following is abridged: During the last month, six special visits have been made, and 199 ordinary visits, making a total of 205 visits. Nine boilers have been examined specially, 504 boilers have been examined externally, 24 internally, and 21 thoroughly, making a total of 558 boilers examined. One engine has been examined especially, and 435 at ordinary visits, from 30 of which indicator diagrams have been taken. The following are some of the principal defects which have been found to exist in the aforesaid number of boilers inspected, and to which the attention of the owners has in each case been called, not only at the time of the visit, but also by a

subsequently written report:—Fracture, 10 (two dangerous); corrosion, 10; safety-valves out of order, 26 (two dangerous); water gauges ditto, 27 (three dangerous); pressure gauges ditto, 13 (one dangerous); feed apparatus ditto, 5; blow-off cocks ditto, 23; fusible plugs ditto, 4; furnaces out of shape, 10; over pressure, 1; deficiency of water, 3 (one dangerous); total, 132 (nine dangerous). Boilers without glass water-gauges, 9; without pressure gauges, 6; without blow-off cocks, 11; without feed check valves, 53. Although nothing of startling interest has occurred during the past month, still the ordinary working of this Association during that period has shown the commercial value of a regular system of boiler inspection, and thus that it has an importance entirely apart from all considerations of the saving of human life and property endangered by boiler explosions. In illustration of this, it was stated that several boilers have been met with, the proprietors of which had gone to the expense of having them fitted with brass scum and mud, or blow-out, taps, as well as the full complement of necessary mountings, and who were under the impression that these were properly attended to, and that all was done that could be to keep their boilers free from deposit, and promote their efficiency and durability; while upon inspection, however, it has been frequently found that these scum and blow-off taps have been quite neglected, and have become choked up with sediment. This has taken some of the proprietors quite by surprise, and they have felt obliged by being undeceived. Some blow-off taps are found to be quite dangerous from their construction, the shells being of cast iron and the plugs of brass, which, on account of their unequal expansion, stick as soon as they are opened, and cannot be closed again, and thus the whole of the water is blown out, the furnace crowns left dry, and the fires have to be drawn. Three tubular boilers were examined during the last month, which have been so injured as to run a stream at the tube ends and other places, mainly from the neglect of suitable blowing out, and will require a removal of all the tubes, and a large outlay upon them, before they will be again fit for use. The value of scum pipes was pointed out, not only on account of their beneficial effect on the boilers themselves, but also on the piston and slides of the engines, by preventing a quantity of earthy matter being carried over in small particles with the steam. It was stated that the water should be blown off from the surface when it is in a state of ebullition, and from the bottom when in a state of rest.—*Proc. Asso. for Prevention of Steam Boiler Explosions*, March 26, 1861.

Preparation of Nitro-Naphthaline.

Into a two-gallon glass globe, 1 kilogramme (2·2 lbs.) of common naphthaline is introduced, with 5 kilogrammes (11 lbs.) of nitric acid of commerce, and the apparatus is arranged in a bath of boiling water. The naphthaline first melts and remains swimming on the liquid; the globe is shaken from time to time, a few red vapors are disengaged,

and the oily stratum sinks to the bottom. In half an hour the operation is finished: the acid is rapidly poured off, and the oily material poured into an earthen vessel, in which it soon solidifies. At the moment of hardening it is divided by stirring it constantly, and it is washed several times to remove the excess of acid. To purify the nitro-naphthaline, it is sufficient to melt it and press it strongly after cooling; when melted it filters through paper as rapidly as water. The cakes of nitro-naphthaline are of a reddish color when in mass, but the powder is of a fine yellow. If the pressure has been sufficiently strong to squeeze out a reddish oil which impregnates the mass, the nitro-naphthaline thus prepared is very pure. Very nearly the theoretic quantity is obtained. The acid mother-waters contain various products, and especially the white bi-nitro-naphthaline, which crystallizes frequently by cooling. They contain also a large quantity of nitric acid, which is slightly tinged of a yellow color, but may be utilized.

Cosmos.

On the Temperature of the Earth's Crust, as exhibited by Thermometrical Observations, obtained during the sinking of the deep Mine at Dukinfield. By W. FAIRBAIRN, LL. D., &c.

From Newton's London Journal, June, 1861.

During the prosecution of researches on the conductivity and fusion of various substances, an opportunity occurred of ascertaining by direct experiments, under favorable circumstances, the increase of temperature in the crust of the earth. This was obtained by means of thermometers placed in bore-holes, at various depths during the sinking of one of the deepest mines in England, namely, the coal mine belonging to F. D. Astley, Esq., at Dukinfield, which has been sunk to a depth of 700 yards.

The increase of temperature in descending, shown by these observations, is irregular; nor is this to be wondered at, if the difficulties of the inquiry and the sources of error are considered, in assuming the temperature, in a single bore-hole, as the mean temperature of the stratum. At the same time, it is not probable that the temperature in the mine-shaft influenced the results. The rate of increase has been shown in previous experiments to be directly as the depth, and this is confirmed by these experiments. The amount of increase is from 51° to $57\frac{3}{4}$° Fahr., as the depth increases from $5\frac{2}{3}$ to 231 yards, or 1° in 99 feet; but in this case the higher temperature is not very accurately determined. From 231 to 685 yards, the temperature increases from $57\frac{3}{4}$° to $75\frac{1}{2}$° Fahr. This is a mean increase of 1° in 76·8 feet, which does not widely differ from the results of other observers. Walferdin and Arago found an increase of 1° in 59 feet; at Rehme, in an artesian well 760 yards deep, the increase was 1° in 54·7 feet; De la Rive and Marcet found an increase of 1° in 51 feet at Geneva. Other experiments have given 1° in 71 feet. The observations are affected by the varying conductivity of the rocks, and by the percolation of water. The author exhibited upon a diagram, in which the ordinates

are depths, and the abscissæ temperatures, the results obtained between the depths of 231 and 717 yards. The strata of the mine were also shown in section. Additional to these, the author gave a table of similar results in another pit at the same colliery, taken between the depths of 167½ and 467 yards, and showing an increase of temperature of 1° in 106 feet of descent.

Assuming, as an hypothesis, that the law thus found for a depth of 790 yards, continues to operate at greater depths, we arrive at the conclusion that at 2½ miles from the surface, a temperature of 212° would be reached; and at 40 miles, a temperature of 3000°, which we may suppose sufficient to melt the hardest rock. The author then discussed the effect of pressure and increased conductivity of the rocks in modifying this result. If the fusing point increased 1·3° Fahr. for every 500 lbs. pressure, as is the case with wax, spermaceti, &c., the depth would be increased from 40 to 65 miles before the fluid nucleus would be reached; but as the same increase is not observed with tin and barytes, the influence of pressure on the thickness of the crust cannot yet be determined. Again, Mr. Hopkins has shown that the conductivity of the dense igneous rocks is twice as great as that of the superficial sedimentary deposits of clay, sand, chalk, &c. And these close-grained igneous rocks are those which we believe must most resemble the strata at great depths. Now, if the conductivity of the lower rocks be twice as great as that of the strata in which the observations were made, correcting our former estimate, we should probably have to descend 80 or 100 miles, instead of 40, to reach a temperature of 3000°, besides the further increase due to the influence of pressure on the fusing point. On entirely independent data, Mr. Hopkins has been led to conclude that the minimum thickness of the crust does not fall short of 800 miles; in which case the superficial temperature of the crust would have to be accounted for from some other cause than an internal fluid nucleus.—*Proc. Manch. Liter. & Philos. Soc.*, April 2d, 1861.

Salubrity of Water-Reservoirs.

M. Coste, of Paris, has discovered that water-reservoirs, in order to preserve their contents wholesome, ought to be protected against heat and light. He found that the exposed reservoir killed all his young fishes. *We wish it would do the same at Fairmount.*

A New Discovery in Gas.

From the London Mining Journal, No. 1338.

The invention of Mr. Webster, of the Phœnix Chemical Works, Birmingham, is at the present moment creating considerable excitement amongst the analytical chemists and scientific men of that borough, and we are, therefore, pleased in being able to publish some of the facts connected with experiments made during the present week, as we think they will prove highly interesting to our readers. Our cor-

respondent attended on Monday evening a meeting held at the above works, at which a large number of gentlemen interested in the subject assembled. From the experiments presented, he elicited the following facts:—That the oxy-carbon gas, patented by Mr. Webster, is a combination in certain proportions of oxygen with certain parts of carbon, the particulars of which he is not at liberty to make known till the publication of the specification, which will shortly appear in this Journal. The light produced by the oxy-carbon gas is one whose purity and brilliancy almost extinguishes the flame of an ordinary gas-light or candle, which looks smoky and opaque when brought into close proximity. The new light is as 16 to 1 of ordinary gas-light. By the application of a reflector the light is thrown to a distance of 20 yards with such effect that a person is enabled to read a letter or the smallest print by it. The radiating heat is not greater than that of ordinary gas, as the oxygen, being supplied from the inner portion of the flame, does not require to partake of the inner air of the room, so that the burner is not consumed or damaged by the action of the flame in any way, but is kept comparatively cool. The oxygen can be absorbed and re-burnt as frequently as desired by a chemical process altogether original, even increasing the value of its properties pecuniarily. The new gas is obtained at a less expense than the ordinary gas, because the oxygen is less expensive by 90 per cent. than that generally employed, since $\frac{1}{4}$ of oxygen would be found equal to $\frac{1}{4}$ of carbon, although securing a register by the photometer of 30 to 1 in favor of the oxy-carbon gas over that in general use. In ordinary gas-light shown to consume 6 feet per hour, the register gives 15 candles, but in the oxy-carbon gas patented by Mr. Webster, the register shown by the photometer, is 240 candles.

Another and a peculiar feature of the new patent gas is that though the burner escapes injury from the flame, the light itself possesses a powerful heat in its centre, which will not only melt iron wire, but platinum and rubies; experiments demonstrated that iron wire twisted was instantly melted, and platinum almost as quickly, when placed in the flame emanating from a blow-pipe. To braziers, jewelers, solderers, &c., it would appear that this invention will be invaluable. Experiments were not only made with ordinary Argand burners, but with oil and paraffin lamps having wicks, each and all of which showed a similar register when the gas was applied. Mr. Webster also exhibited a lamp for light-houses, to which he demonstrated by experiment his oxy-carbon was equally applicable. We understand that Mr. Wilkins, the engineer from Trinity House, London, has been down to Birmingham to witness Mr. Webster's experiments, and that arrangements are being made for lighting up with the oxy-carbon gas the light-houses of that establishment. The apparatus of Mr. Webster is remarkably simple in its construction, so much so indeed that an ordinary person can generate the gas and arrange the light. The new gas is not explosive, and can be regulated to any extent, so as to adapt it to a private office or room, to a public building, to street light, or light-houses, and to railways and railway carriages. One

light in a public building or manufactory will be equal to sixteen ordinary gas lights; and the inexpensive character of its production will, it is asserted, reduce the expenditure of lighting at least ninety per cent. The gentlemen present appeared to be highly delighted with the successful experiments of Mr. Webster, and retired acknowledging that the light in question was all he had represented it to be, and thanking him for the demonstrations which he had kindly presented. We understand that a company is in the course of formation for the purpose of carrying out the principle of the new patent.

To Prevent Chimneys from Smoking.

A *M. de Sauges*, an architect, submits to the French Academy of Sciences a *novel plan* for preventing chimneys from smoking and increasing their draft. It consists in opening all the flues into a chamber built just under the peak of the roof; and he proposes, moreover, to put a reservoir here, so as to furnish hot water for the house.—*Cosmos.*

Extracts of Statistics of Cotton Manufacture. From the Seventh Annual Report of the Boston Board of Trade, 1861.

From the above statements we obtain the following results as to the progressive increase of the number of spindles in Massachusetts.

	Spindles.	Increase.	Per cent.
In 1831,	339.777		
1840,	624,540	284,763	83
1845,	817,483	191,143	30
1850,	1,288,091	470,608	57
1855,	1,519,527	231,436	18
1860,	1,688,471	168,944	11

From 1850 to 1860, the number had increased 400,380, being 31 per cent. upon the number in 1850, in ten years.

In the Massachusetts Statistics for 1845, the consumption of cotton is stated at 56,851,654 lbs., which, divided by the number of spindles, 817,483, gives per spindle, per year, 69·54 lbs. According to the census of 1850, the consumption is estimated at 223,607 bales, which, multiplied by 425 lbs., the average weight of bales at that time, gives 95,032,975 lbs.;—this, divided by 1,288,091, the number of spindles at that time, gives per year 73·70 lbs.

According to Massachusetts Statistics of 1855, the number of pounds of cotton was 105,851,749, which, divided by the number of spindles, 1,519,527, gives 69·66 lbs.

There is always some uncertainty about quantities stated in such reports, which are frequently furnished by estimation, rather than from actual weights and measures, which may account for the difference of the result in 1850, from the remarkable agreement in the weight at the two other periods named. This difference may be accounted for

by the circumstance that the weight of cotton is obtained, in this instance, by multiplying the number of bales by an assumed average weight per bale. I have the particular statistics from more than thirty different mills, varying from about 150 lbs. of cotton per year, on coarse goods, to about 50 lbs. per spindle on finer fabrics; so that, I think, from about 70 to 75 lbs. per spindle would be a fair average in this country.

I likewise get from those returns, where the value of the goods manufactured is given, the average value of goods per spindle.

In Massachusetts, by the "Statistics of 1845," the value was $ 11,164,212, which, divided by 817,483 spindles, gives for value per spindle, .	$ 13·65
By census of 1850, $ 19,712,461, divided by 1,288,091 spindles,	15·30
By Massachusetts Statistics, 1855, $ 24,359,212, divided by 1,519,527 spindles, ...	16·03

These results agree very nearly with the actual value derived from the accounts of several mills in Massachusetts, New Hampshire, and Maine, varying from $ 12·75 to $ 16·60 per spindle for the value of product, or cost of material and labor per year, the variation being much less than in the pounds of cotton per spindle, because where the labor is less on the coarser article, the quantity and cost of material will be more.

From a number of reports where the yards produced are stated, I obtain the following results as to the number of yards per spindle, per year:

In 1831, the yards in Massachusetts are stated at 79,231,000. Divided by the number of spindles, 339,777, the number of yards would be . . .	233 yards.
In 1845, according to Massachusetts Statistics, yards 175,-682,919, spindles 817,483, . .	214 "
According to the census of 1850, the yards are given, in the United States, 298,751,392, and by the statement of De Bow, the number of spindles is 1,288,091, .	231 "
According to the census of 1850, the number of yards in New England was 596,867,507, which, divided by spindles, according to De Bow, 2,751,078, gives . .	216 "
In 1855, Massachusetts Statistics, the yards are stated at 314,-996,567, divided by 1,519,527, . .	207 "

The concurrence of these results, differing only ten or twelve per cent. from the highest to the lowest, gives confidence in the accuracy of the reports.

* * * * * * *

It has been estimated that the consumption of cotton *per capita*, in England, amounts to $4\frac{3}{4}$ lbs. and to $13\frac{1}{4}$ yds. In this country,

In 1830, . . .	to 4 lbs.,	12 yards.
1840, . . .	to 7 "	21 "
1850, . . .	to $10\frac{3}{4}$ "	$32\frac{1}{4}$ "

The various reports and tables I have examined give the following results, as to the number of yards per pound of cotton:

The Statistics of Massachusetts for 1845, . .	3·09 yards.
The Census of the United States, 1850, .	2·80 "
On the same authority, for the manufactures of Massachusetts in 1850, . . .	3·14 "
Statistics of Massachusetts, 1855, . .	2·97 "

As to the cost or value per yard, that is, cost of labor and material.

By Massachusetts Statistics, 1845, . .	6·35 cents.
Census of United States, 1850, . .	8·10 "
Massachusetts Statistics, 1855, . .	7·76 "

In 1845 it will be remembered that the price of cotton was very low.

The exportation of American Cotton Goods has increased very much during the last year, being, according to the Report of the Secretary of the Treasury upon the Finances of December 4, 1860, for

The year ending June 30, 1860, . .	$ 10,934,796
" " " 1859, .	8,316,222
Increase,	$ 2,618,574

It is understood, that of the exports of last year, the amount of $ 4,200,000 went directly to China, from the ports of New York and Boston.

The exports of last year, as above, are nearly half the amount of our imports of Cotton Manufactures from Great Britain.

A late article in the Economist states the total exports of Great Britain at . . .	£ 130,440,000
Of which cotton goods and yarn constituted .	48,200,000
Of which sum the United States took . .	4,635,000

It is supposed that the manufacturing machinery in Great Britain has increased very rapidly for several years past. In Ellison's Handbook, p. 147, we have from the reports of the Factory Inspectors the following statements for 1850 and 1856.

1850.	Spindles.	Looms.
England and Wales, . .	19,173,969	223,626
Scotland, . .	1,683,093	23,564
Ireland, . . .	119,925	1,437
	20,976,987	248,627
1856.		
England and Wales, . .	25,818,576	275,590
Scotland, . .	2,041,139	21,624
Ireland, . . .	150,502	1,633
	28,010,217	298,847

The increase of spindles in six years would therefore be 7,033,200, or nearly 30 per cent.

If we take the same rate of increase for four years to 1860, say 20 per cent., it would be . . .	5,602,043
Adding the number as above, . .	28,010,217
It would make the number in 1860, . .	33,612,260

and the same rate of increase would give the number of looms, 358,-615.

According to a paper read by Mr. Ashworth about a year ago, and published in the *Manchester Guardian*, the cotton consumed in Great Britain in 1850 was 629,798,400 lbs., which, divided by the number of spindles, 20,977,000, would average about 30 lbs. per spindle. He

estimates the consumption of cotton last year at 973,800,800 lbs., which at 30 lbs. per spindle would indicate the number of spindles in 1860 to be 32,460,026, being something less than the number which I derive from the per centage of increase. This estimate of 32,460,026 spindles would give an increase in ten years from 1850 of 11,483,987 spindles, or about 55 per cent. The preceding estimates for the increase in this country, in the same time, would give 726,727 spindles, or 20 per cent.

The average number of spindles to the loom is 84, being about twice the proportion in this country, which is the result of the quantity of yarn made for export, and in some degree to the extra speed of their looms.

In Ellison's Hand-book, p. 138, is an estimate of the consumption of cotton for 1856, at 920,000,000 lbs., which, divided by the number of spindles at that time, 28,010,217, would give 32·8 lbs. per spindle.

The value of the goods produced is also stated at £ 64,484,000, which would amount to $ 11·00 per spindle, being less than the average value in this country, on account of the lighter and finer quality of the goods.

We have had from time to time, for several years past, newspaper publications and calculations, to show the astonishing increase of cotton machinery in Great Britain, and estimates are made as high as ten or fifteen per cent. per annum, or, as it is sometimes stated, as many spindles per year as all we have in operation in the United States. Their machinery is no doubt increasing very fast, and during the past year probably faster than usual; but there is a great tendency to extravagance in all these estimates, sometimes founded upon verbal reports of the large number of spindles building under contract, which are all set down as completed and in operation, and sometimes on the sanguine calculations and anticipations of those whose standing and general knowledge of the business, gives confidence to their speculations.

In the Trade circular of a Manchester house, under date of February 27, 1857, there is a very elaborate statement of the increase of cotton machinery from 1850 to 1856, to show, that if the next crop of cotton in the United States did not exceed three millions five hundred thousand bales, the supply would be exhausted by the close of the year 1858, and the consequences were predicted to be such as to justify the great alarm felt by the cotton spinners. And so long ago as 1847, it was confidently predicted by Mr. Baynes, from the ratio of increase of machinery for the twelve preceding years, that the cotton required for the year 1858 would be 5,810,000 bales, of which it would be necessary that the United States should furnish 5,055,000 bales (Ellison's Hand-book, p. 136). Now it turned out that neither of the foregoing predictions were fulfilled. The crop of 1857–8, in the United States, was 3,113,962 bales, or more than 1,900,000 bales short of the number contemplated by Mr. Baynes, and yet there was no deficiency, but an increasing stock on hand at the close of the year.

These results seem to show that the increase of cotton machinery has been over-estimated by intelligent manufacturers, in years past. Yet notwithstanding the failure of these, and similar predictions, there continues to be a prevailing impression, that the increase of cotton machinery was going beyond the increase in the cultivation and production of cotton, and this opinion has been propagated with great zeal and success at the South, for the benefit of the market, and has gained such a currency in England, as to increase their alarm as to obtaining a supply for their spindles, even when there were no obstructions in their way as at present. It may be worth while to examine this subject, even though, under present circumstances no benefit may be derived from it as to the future.

The average number of bales of cotton per year, for the crop of the five years, 1856 to 1860 inclusive, appears by the yearly cotton statistics to be . . .	3,621,715
For the five years, 1846 to 1850, . .	2,210,425
Increase in ten years, . . .	1,411,290

This increase is 64 per cent.

According to the preceding statements of the increase of machinery in Great Britain, from 1850 to 1860, it was 55 per cent., and this is confirmed on the authority of Mr. Ashworth, who states the increase of the consumption of cotton in ten years, from 1849 to 1859, to be as follows:

In 1859, . . .	973,800,800
In 1849, . . .	629,798,400
Increase of consumption in ten years, . .	344,002,400

which is $54\frac{6}{10}$ per cent.

Now, taking the increase of spindles in Great Britain from 1850 to 1860, at 55 per cent., and in other parts of Europe at something less, and in this country certainly not to exceed 25 per cent., the whole increase cannot be more than 50 per cent., against an increase of the cotton crop in the same time, of 64 per cent.

After this unexpected result, the inquiry arises,—How has it happened that such a manifest error has prevailed so extensively, year after year, both in this country and in England, while no deficiency of a supply has been experienced, and the stock on hand at the end of several years has been rather increasing? This is one of the mysteries of trade, and we may sometimes see articles upon the "Supply of Cotton," and upon the "Future of Cotton," published and republished, from one side of the Atlantic to the other, that give us a glimpse of light upon the subject, and show how public opinion may sometimes be made to order.

The stock of American cotton at Liverpool is reported as follows:

	Bales.	Increase.
At close of the year 1857, . .	198,740	
" " " 1858, . .	264,810	66,070
" " " 1859, . .	301,000	36,190
" " " 1860, . .	403,000	102,000

This will confirm the foregoing calculations, and show that instead

of the machinery increasing beyond the power of the cotton crop to supply the spindles, as has been predicted for some years past, the supply of cotton has been increasing beyond the spindles.

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 10.

SHAFTS AND GUDGEONS.

(Continued from page 42.)

SHAFTS are divided into *Shafts* and *Spindles*, according to their magnitude.

A *Gudgeon* is the metal journal or arbor on which a wooden shaft revolves.

Shafts are subjected to Torsion* and Lateral stress combined, or to Lateral stress alone.

LATERAL STIFFNESS AND STRENGTH.

Shafts of equal length have *lateral stiffness* as their breadth and the cube of their depth, and have *lateral strength* as their breadth and the square of their depths.

Hence, in shafts of equal lengths, their stiffness by any increase of depth, increases in a greater proportion than their strength.

Shafts of different lengths have *lateral stiffness*, directly as their breadth and the cube of their depth, and inversely as the cube of their length, and have *lateral strength* directly as their breadth and as the square of their depth, and inversely as their length.

Hence, in shafts of different lengths, their stiffness by any increase of their length, decreases in a greater proportion than their strength.

Hollow shafts having equal lengths and equal quantities of material, have *lateral stiffness* as the square of their diameter, and have *lateral strength* as their diameters.

Hence, in hollow shafts, one having twice the diameter of another, will have four times the stiffness and but double the strength, and when having equal lengths, by an increase in diameter they increase in stiffness in a greater proportion than in strength.

The stress upon a shaft from a weight upon it, is proportional to the product of the parts of the shaft multiplied into each other.

Thus, if a shaft is 10 ft. in length, and a weight on the centre of gravity of the stress, is at a point 2 feet from one end, the parts 2 and 8 multiplied together are equal to 16; but if the weight or stress were applied in the middle of the shaft, the parts 5 and 5 multiplied together would produce 25.

The ends of a shaft having to support the whole weight, the end which is nearest the weight has to support the greatest proportion of it, in the inverse proportion of the distance of the weight from the

* For Rules for Torsional Strength, see page 37.

end. *Hence*, when a shaft is loaded in the middle, each of the journals or gudgeons has half the weight or stress to support.

When the load upon a shaft is uniformly distributed over any part of it, it is considered as united in the middle of that part, and if the load is not uniformly distributed, it is considered as united at its centre of gravity.

When the transverse section of a shaft is a regular figure, as a square, circle, &c., &c., and the load is applied in one point, in order to give it equal resistance throughout its length, the curve of the sides becomes a cubic parabola; but when the load is uniformly distributed over the shaft, the curve of the sides becomes a semi-cubical parabola.

The deflection of a shaft produced by a load which is uniformly distributed over its length, is the same as when five-eighths of the load is applied at the middle of its length.

The resistance of the body of a shaft to lateral stress, is as its breadth and the square of its depth: *hence*, the diameter will be *as the product of the length of it and the length of it one side of a given point, less the square of that length.*

Illustration.—The length of a shaft between the centres of its journals is 10 feet: what should be the relative cubes of its diameters when the load is applied at 1, 2, and 5 feet from one end? and what when the load is uniformly distributed over the length of it?

$l \times l^1 - l^2 = d^3$, and when uniformly distributed $d^3 \div 2 = d^1$.
$10 \times 1 = 10 - 1^2 = 9 =$ *cube of diameter* at 1 foot.
$10 \times 2 = 20 - 2^2 = 16 =$ " " 2 "
$10 \times 5 = 50 - 5^2 = 25 =$ " " 5 "

When a load is uniformly distributed, the stress is greatest at the middle of the length and is equal to half of it; if collected in the middle, and when the load is uniformly distributed—

$25 \div 2 = 12{\cdot}5 =$ *cube of diameter at 5 feet.*

Cylindrical Shafts.

To Ascertain the Diameter of a Cast Iron Shaft to resist Lateral Stress alone.

When the Stress is in or near the Middle.

Rule.—Multiply the weight by the length of the shaft in feet, divide the product by 500, and the cube root of the quotient will give the diameter in inches.

Example.—The weight of a water-wheel upon a shaft is 50,000 lbs., its length 30 ft., and the centre of gravity of the wheel 7 ft. from one end; what should be the diameter of its body?

$\sqrt[3]{\left(\frac{50{,}000 \times l}{500}\right)} = 14{\cdot}422$ *ins., if the weight was in the middle of its length.*

Hence, the diameter at 7 ft. from one end will be, as by preceding rule, $30 \times 7 - 7^2 = 161 =$ *relative cube of diameter at 7 ft.*

$30 \times 15 - 15^2 = 225 =$ *relative cube of diameter at 15 ft.*

Then as $\sqrt[3]{225}$: 14·42 : : $\sqrt[3]{161}$: 12·89 *ins., the diameter of the shaft at 7 ft. from one end.*

When the Stress is Uniformly Laid along the Length of the Shaft.

Rule.—Divide the cube root of the product of the weight and the length by 9·3, and the quotient will give the diameter in inches.

Example.—Apply the rule to the preceding case.

$$\frac{\sqrt[3]{50{,}000 \times 30}}{9{\cdot}3} = 12{\cdot}31 \textit{ ins.}$$

Or, *when the diameter for the stress applied in the middle is given.*

Rule.—Take the cube root of five-eighths of the cube of the diameter, and this root will give the diameter required.

Example.—The diameter of a shaft when the stress is uniformly applied along its length is 14·422 ins. What should be its diameter, the stress being applied in the middle.

$$\sqrt[3]{\tfrac{5}{8} \times 14{\cdot}422^3} = \sqrt[3]{\tfrac{5}{8} \times 3000} = 12{\cdot}33 \textit{ ins.}$$

Hollow Shafts of Cast Iron.

When the Stress is in or near the Middle.

Rule.—Divide the continued product of ·012 times the cube of the length and the number of times the weight of the shaft in pounds by the sum of the internal diameter added to 1, and twice the square root of the quotient added to the internal diameter, will give the whole diameter in inches.

Example.—The weight of a water-wheel upon a hollow shaft 30 ft. in length is 2·5 times its own weight, and the internal diameter is 9 ins.; what should be the whole diameter of the shaft?

$$\sqrt{\left(\frac{{\cdot}012 \times 30^3 \times 2{\cdot}5}{1 + 9^2}\right)} = \sqrt{\frac{810}{82}} = 3{\cdot}14 \textit{ ins.}$$

Then $9 + \overline{3{\cdot}14 \times 2} = 15{\cdot}28$ *ins., the whole diameter.*

To ascertain the Diameter of a Cast Iron Shaft to resist its own weight alone.

Rule.—Multiply the cube of its length by ·007, and the square root of the product will give the diameter in inches.

Example.—The length of a shaft is 30 feet; what should be its diameter in the body?

$$\sqrt{(30^3 \times {\cdot}007)} = \sqrt{189} = 13{\cdot}75 \textit{ ins.}$$

When a Shaft has to resist both Torsional and Lateral Stress combined.

To ascertain its Diameter, the Stress being applied in the Middle.

Rule.—Ascertain the diameter for each stress, and the cube root of the sum of their cubes will give the diameter required.

Example.—The diameter of the journal of a shaft to resist torsional stress is ascertained to be 17 ins., and the diameter of its body in the

centre to resist lateral stress, has also been ascertained to be 14·422 ins.; what should be the diameter of the body?

$$\sqrt[3]{(17^3 + 14{\cdot}422^3)} = \sqrt[3]{7913} = 19{\cdot}927 \textit{ ins.}$$

The strength of a cylindrical shaft compared to a square one, the diameter of the one being equal to the side of the other, is as 1 to 1·7, and of a square shaft to a cylindrical as 1 to ·589.

To ascertain the Diameter of Shafts of Wrought Iron, Oak, and Pine.

Multiply the diameter ascertained for cast iron as follows:

Wrought iron	by	·935
Oak	"	1·83
Yellow pine,	"	1·716

To ascertain the Deflection of a Cylindrical Shaft.

Rule.—Divide the square of three times the length in feet by the product of the following *Constants* and the square of the diameter in inches, and the quotient will give the deflection.

Cast iron,	Cylindrical shaft,	.	1500
do.	Square do.	.	2560
Wrought iron,	Cylindrical do.	.	1980
do.	Square do.	.	3360

Example.—The length of a cast iron cylindrical shaft is 30 ft. and its diameter in the centre 15 ins.; what is its deflection?

$$\frac{\overline{30 \times 3}^{\,2}}{1500 \times 15^2} = \frac{8100}{337500} = {\cdot}024 \textit{ ins.}$$

To ascertain the Length of a Cylindrical Shaft.

Rule.—Multiply the preceding *constant* by the deflection, and the square of the diameter and one-third of the square root of the product will give the length in feet.

Example.—The diameter of a cast iron cylindrical shaft is 15 ins. and the deflection assigned to it is ·024; what should be its length?

$$\sqrt{\frac{1500 \times {\cdot}024 \times 15^2}{3}} = \frac{90}{3} = 30 \textit{ ft.}$$

Gudgeons.

To ascertain the Diameter of a Single Gudgeon to Support a given Stress or Weight.

Rule.—Divide the square root of the weight in pounds by 25 for cast iron, and 26 for wrought iron, and the quotient will give the diameter in inches.

Example.—The weight on a gudgeon of a cast iron water-wheel shaft is 62,500 lbs.; what should be its diameter?

$$\sqrt{\frac{62{,}500}{25}} = \frac{250}{25} = 10 \textit{ ins.}$$

(To be Continued.)

Description of a New Optical Instrument called the "Stereotrope." By WILLIAM THOMAS SHAW, Esq. Communicated by WARREN DE LA RUE, Esq.

This instrument is an application of the principle of the stereoscope to that class of instruments variously termed thaumatropes, phantascopes, phenakistoscopes, &c., which depend for their results on "persistence of vision." In these instruments, as is well known, an object represented on a revolving disc, in the successive positions it assumes in performing a given evolution, is seen to execute the movement so delineated; in the stereotrope the effect of solidity is superadded, so that the object is perceived as if in motion and with an appearance of relief as in nature. The following is the manner in which I adapt to this purpose the refracting form of the stereoscope.

Having procured eight stereoscopic pictures of an object—of a steam engine for example—in the successive positions it assumes in completing a revolution, I affix them, in the order in which they were taken, to an octagonal drum, which revolves on a horizontal axis beneath an ordinary lenticular stereoscope and brings them one after another into view. Immediately beneath the lenses, and with its axis situated half an inch from the plane of sight, is fixed a solid cylinder, 4 inches in diameter, capable of being moved freely on its axis. This cylinder, which is called the eye-cylinder, is pierced throughout its entire length (if we except a diaphragm in the centre inserted for obvious reasons) by two apertures, of such a shape, and so situated relatively to each other, that a transverse section of the cylinder shows them as cones, with their apices pointing in opposite directions, and with their axes parallel to, and distant half an inch from, the diameter of the cylinder. Attached to the axis of the eye-cylinder is a pulley, exactly one-fourth the size of a similar pulley affixed to the axis of the picture-drum, with which it is connected by means of an endless band. The eye-cylinder thus making four revolutions to one of the picture-drum, it is evident that the axes of its apertures will respectively coincide with the plane of sight four times in one complete revolution of the instrument, and that, consequently, vision will be permitted eight times, or once for each picture.

The cylinder is so placed that at the time of vision the *large* ends of the apertures are next the eyes, the effect of which is that when the *small* ends pass the eyes, the axes of the apertures, by reason of their eccentricity, do not coincide with the plane of sight, and vision is therefore impossible. If, however, the position of the cylinder be reversed end for end, vision will be possible only when the small ends are next the eyes, and the angle of the aperture will be found to subtend exactly the pencil of rays coming from a picture, which is so placed as to be bisected at right angles by the plane of sight. Hence it follows that, the former arrangement of the cylinder being reverted to, the observer looking along the upper side of the aperture will see a narrow strip extending along the top of the picture; then, moving the cylinder on and looking along the lower side of the aperture, he

will see a similar strip at the bottom of the picture; consequently, in the intermediate positions of the aperture, the other parts of the picture will have been projected on the retinæ. The width of these strips is determined by that of the small ends of the apertures, which measure ·125 inch; and the diameter of the large ends is 1·5 inches, the lenses being distant 9 inches from the pictures. The picture-drum being caused to revolve with the requisite rapidity, the observer will see the steam engine constantly before him, its position remaining unchanged in respect of space, but its parts will appear to be in motion, and in solid relief, as in the veritable object. The stationary appearance of the pictures, notwithstanding the fact of their being in rapid motion, is brought about by causing their corresponding parts to be seen, respectively, *only* in the same part of space, and *that* for so short a time that while in view they make no sensible progression. As, however, there is an actual progression during the instant of vision, it is needful to take that fact into account—in order that it may be reduced as far as practicable—in regulating the diameter of the eye-cylinder, and of the apertures at their small ends; and the following are the numerical data involved in the construction of an instrument with the relative proportions given above:—

The circumference of picture-drum = 22·5 inches (A).

The circumference of eye-cylinder = 12 inches × 4 revolutions = 48 inches (B).

The diameter of apertures at large ends = 1·5 inch (C).

The diameter of apertures at small ends = ·125 inch (D).

While the large end is passing the eye, the picture under view progresses $\frac{1{\cdot}5\ (C)}{48\ (B)}$ of 22·5 (A), or ·703 inch.

This amount of progression (·703 in.), if perceived at one and the same instant, would be utterly destructive of all distinctness of definition; but it is evident that the total movement brought under visual observation at any one moment is $\frac{{\cdot}125\ (D)}{1{\cdot}5\ (C)}$ of ·703 inch, or ·058 inch. This movement must necessarily occasion a corresponding slurring, so to speak, of the images on the retina; and the fact of such slurring not affecting, to an appreciable extent, the distinctness of definition, seems to be referable to a faculty which the mind has of correcting or disregarding certain discrepant appearances or irregularities in the organ of vision; as a further illustration of which I may cite the fact, mentioned by Mr. Warren de la Rue in his "Report on Celestial Photography," that the retinal image of a star is, at least under some atmospheric conditions, made up of "a great number of undulating points," which, however, the mind rightly interprets as the effect of the presence before the eye of a single minute object. That this corrective power is, as might be supposed, very limited, may be proved experimentally by this instrument; for if the small ends be enlarged in only a slight degree, so as to increase this slurring on the retinæ,

a very marked diminution in clearness of definition is the immediate result.

That form of the stereotrope, in which Professor Wheatstone's reflecting stereoscope is made use of, and which is better adapted for the exhibition of movements that are not only local but progressive in space, it is needless to describe here, because the principles it involves are essentially the same as those which are stated above.

Proceedings of the Royal Society, Jan. 10, 1861.

New Blasting Powder.

From the London Builder, No. 952.

Some blasting powder, made by Mr. Laurence Geoghegan, gunmaker, Galway, from tanner's waste bark, nitrate of soda, and sulphur, is spoken of by the *Galway Vindicator*. Mr. Samuel U. Roberts, Engineer to the Board of Public Works, under whose superintendence the extensive drainage works in the Galway district were carried to completion, says, in a certificate as to Mr. Geoghegan's powder: "In my presence he inserted a small quantity of it (much less than would be required of the ordinary blasting powder) into a jumper-hole 1 inch in diameter and 15 inches deep, in a very solid boulder rock of hard granite containing about 30 cubic feet. On being ignited in the ordinary manner with a fuse, it burst the rock into fragments without making a report or causing spawls to fly from it; so that a person might safely stand within a short distance without incurring danger. Mr. Geoghegan states that this powder can be sold at half the price of the ordinary blasting powder. I am of opinion that it is much stronger than that which is now generally in use for blasting purposes."

The Conduction of Heat by Gases. By G. Magnus.*

From the Lond. Engineer, No. 267.

The cooling of a body *in vacuo* depends simply on the exchange of heat by radiation between the cooling mass and the encircling envelope. If the space contains gas, an ascending current is formed, which accelerates the cooling, added to which the property which the gas has of transmitting heat, or its diathermancy, concurs in producing cooling, provided the gases can conduct heat. Dulong and Petit, in enunciating their law of the loss of heat, have neglected the last two actions, manifestly because they are infinitely small compared with the influence of the ascending currents. Since then, it has been universally admitted that the differences in the cooling of the different gases depend on the different mobility of their particles. Cooling takes place much more rapidly in hydrogen than in other gases. With the same amount of heat, this gas expands not more, but less, than atmospheric air; the changes in density in the former gas are less than the latter. But it is the difference of specific gravity which pro-

* Translated from the *Bericht der Berliner Akedemie*, 1860, p. 485.

duces currents. If, therefore, different gases by contact with a warmer body all become equally heated, the currents in those gases which have a greater co-efficient of expansion must be greater than in the rest; for example, in carbonic acid more than in hydrogen. As this is not the case, it must either be assumed that the friction of the gaseous particles against each other is so great that the influence of the greater expansion is neutralized by it, which will with difficulty be admitted, or it must be assumed that gases by contact with a hot body become heated to a different extent. Such a difference in the degree of heat would take place if the gases had different capacities for heat; but as the specific heats of hydrogen and atmospheric air are the same, there remains no other explanation for the more rapid cooling in hydrogen, than that this gas can transmit heat from particle to particle, in other words, can conduct it, and that it possesses this property in a higher degree than other gases. Its low density appeared to be in disaccordance with this idea, and it appeared necessary to decide by experiments how far it is founded.

The impulse to these experiments was given by a repetition of Mr. Grove's interesting observation, according to which a platinum wire is less strongly heated when surrounded by hydrogen than by atmospheric air, or another gas. In this repetition, it was found that hydrogen exerted its preventive action even when a layer only 0·5 mil. thick surrounded the wire, and it was the same whether the tube containing it was in a horizontal or vertical position. In such a narrow tube, especially when it is horizontal, currents can scarcely occur; and when there are none, there remains no other explanation than that hydrogen conducts heat better than other bodies.

The simplest mode of ascertaining whether a gas conducts heat, consists in warming it from above, and observing the action on a thermometer placed within. It might be objected to this method that, even with heating from above, currents in the gas might be formed, and that thereby the temperature indicated by the thermometer in various gases might be different without any difference in conductibility.

There is one method of testing this objection. For if, in fact, a gas can conduct heat, the temperature assumed by a thermometer in a space heated from above must be lower when the conducting substance is wanting than when it is present; that is, it must be lower *in vacuo* than in a space filled with air.

In order to ascertain whether this was the case, a glass apparatus was used, in which a thermometer, observable from without, was firmly fixed. It could be filled with different gases, and these could be variously dilated. The upper part of this apparatus was maintained at the same temperature, namely, that of boiling water, and the temperature was observed which a thermometer introduced into the interior ultimately assumed. Of course the experiments with this apparatus were not made without numerous precautions; it was more particularly necessary that the whole apparatus should be always under the same conditions, so as to give off the heat imparted to it always in

the same manner. For this it was necessary that the space surrounding it should always be at the same temperature. In these experiments, the temperature of the surrounding space was 15°.

In this way, the following results were obtained:—1. The temperature which a thermometer ultimately assumes in a space heated from above, differs when this space is filled with different gases. 2. In hydrogen, the temperature is higher than in any other gas. 3. In this gas, the temperature is higher than *in vacuo;* and the denser the gas is, the higher is the temperature. 4. Hence, hydrogen conducts heat like metals. 5. In all other gases, the temperature is lower than *in vacuo;* and the denser they are, the lower is the temperature. 6. It cannot hence be concluded that gases do not conduct heat, but only that they do this in so small a degree that the action of conduction is cancelled by their diathermancy. 7. This remarkable property of hydrogen is evinced not only when it moves freely, but also when it is contained between eider down, or any loose substance which hinders its motion. 8. The great conductibility of this gas is a further confirmation of its analogy with metals. 9. Hydrogen conducts not only heat, but also electricity, better than other gases.

The Victoria Falls.

From the London Engineer, No. 278.

Dr. Livingstone has written a letter to Sir Roderick Murchison, giving the following corrected particulars of the great African cataract:—" The river was so low we could easily see the bottom of one-half of the fissure which forms Victoria Falls; and, indeed, people could wade from the north bank to my Garden Island, to form a stockade for fresh seeds. The depth is not 100 ft., but 310 ft.—probably a few feet more, as the weight attached to the line rested on a slope near the bottom. The breadth from bank to bank is not 1000 yards, as I conjectured in 1855, but between one statute and one geographical mile—we say 1860 yards to assist the memory, but it is a little more, yet not quite 2000 yards. The lips of the crack at Garden Island may be more than 80 ft., as we could not throw a stone across; but the sextant gave that. Now come to the other or south-eastern side of the crack, and the fissure, which from the upper bed looks like the letter L, is prolonged in a most remarkable zigzag manner. The water, after leaping sheer down 310 ft., is collected from both ends to the upright part of the letter as the escape, and then flows away on the zigzag part. The promontories formed thereby are flat at the top, and of the same level as the bed of the river above the Falls. The base of the first on the right is only 400 paces from the Fall fissure, and that on the left about 150. Their sides are as perpendicular as the Fall, and you can walk along among the trees, and by a few steps see the river some 300 ft. or 400 ft. below, jammed in a space of some 20 or 30 yards, and of a deep green color. As a whole, the Victoria Falls are the most wonderful in the world. Even now, at

extreme low water, or when it is 2 ft. lower than we ever saw it, there are 800 ft. of water falling on the right of Garden Island. And the two columns of vapor, with the glorious rainbows, are a sight worth seeing. A fall called Momba, or Moamba, below this, is interesting, chiefly because you look down it from a height of some 500 ft. It is really nothing after Mosioatunya."

New Mode of Preserving Impressions in Sand, &c.

From the London Engineer, No. 258.

The murder of President Poinsot, on the Lyons Railway, has given rise to a very ingenious plan of rendering permanent marks in sand or any other yielding soil, and which may possibly be found useful in many cases where it is desirable to preserve an impression that would otherwise be soon obliterated. The process is the invention of M. Hugoulin, an apothecary in the Imperial navy, and the manner in which it has been applied to preserve the marks made by the criminal Jud in the sandy ground of the station at Noisy-le-Sec, where he leapt from the train, is as follows:—A sheet of thin iron plate was placed over the marks made, and supported by an iron stand at a distance of about an inch and a half from the surface of the ground, a quantity of lighted charcoal was then placed on the iron plate, which soon became red-hot, and of course heated the spot over which it was placed. When the latter was raised to about 100° Centigrade (212° Fahr.), the fire, together with the plate, was removed, and a quantity of finely divided stearic acid was strewed over the impressions by means of a sieve. The powder used was that of a common *bougie*, or stearine candle, dissolved by heat in alcohol, and then thrown into a large quantity of cold water, when the stearine falls to the bottom in the form of a fine precipitate. This powder is so light and impalpable, that it is said it might be sifted over an impression in the dust of a common road without in the slightest degree interfering with the faintest mark. The instant it touched the heated surface of the ground in question, it melted, and, as it were, sealed the whole of the loose atoms into one compact mass. When a sufficient quantity of the stearine had been applied, the place was left until it had become completely cold; the surrounding earth was then dug out carefully at some little distance from the edges of the impression, and the portion containing this latter was lifted up in one entire block, and laid on a cloth several times doubled, the edges of which were raised up so as to form a kind of border, or rather framing, into which and against the sides of the sandy earth containing the impression, plaster of paris was poured, and when the latter was set, the whole could be handled without danger, and was firm enough to bear packing and carriage to any distance. It is evident, therefore, that, if necessary, it might also be used as a mould, from which casts in plaster could be obtained. The value of such a process as an aid in criminal cases is too self-evident to require demonstration; the production of the tell-tale impression in a court of laws where every mark can be conveniently exhibited and compared

with the object by which it was produced, may be equally useful in the proof of guilt and of innocence, and it would be strange indeed if a use for such a process be not discovered in matters of scientific or practical interest.—*Building News.*

The New Mortar Cannon.

From the London Engineer, No. 270.

The *Times*' Paris correspondent thus refers to this new weapon:—The tube or barrel is formed of several cylinders or rings of cast or wrought iron, its longitudinal cylindrical parts affording the means of uniting the rings. The interior of the tube is rifled by means of a certain number of projecting spiral rods shaped in triangular prisms. The tube can be lengthened at pleasure. The breech of the gun is a mortar, to which the tube is attached, and from which it may be detached, either for the purpose of loading it at the breech or of making use of it as a mortar. It is alleged that this cannon cannot become heated, that the process of cleansing after each discharge is unnecessary, except as regards the breech, and that it may be fired five times during the space now required to fire any other gun once. Another consequence said to follow from the non-heating of the barrel of the gun is, that there is no danger of bursting, either from defect in the metal or from over-charge. The gun may likewise be lengthened or shortened at pleasure. The inventor states that a gun throwing a shot of 120 pounds weight may be taken to pieces and conveyed on the back of a horse or mule over roads impassable for carriages. He shows that there is a considerable saving in the construction of this gun in consequence of the tube being of openwork, and of iron, in place of bronze. It may be as light as is consistent with the resistance which its weight must necessarily oppose to the recoil produced by its discharge. The inventor expects that this gun will supersede mortars, and that every cannon mounted on a ship's deck may be used both as a cannon and a mortar, and that a ship which carries forty guns may be said to carry forty guns and forty mortars.

On the Conversion of Iron into Steel.

From the Lond. Engineer, No. 275.

Last week M. Frémy communicated to the Academy of Sciences a second paper on his researches touching the conversion of iron into steel. Our readers will remember that in his first communication he chiefly limited himself to the question of determining the quantity of nitrogen which should be combined with iron, in order to render it convertible into good steel. M. Frémy in his second paper undertakes to prove that steel is not a carburet of iron, as has hitherto been supposed, but that there exists a series of combinations of iron with metalloids, metals, and even with cyanides, yielding steel of very good quality. He states, in the first place, that steel, when dissolved in

acids, leaves a residue different from pure carbon, but closely resembling certain cyanides. He then proceeds to show that if common iron, in its metallic state, be subjected for the space of two hours to the action of common illuminating gas (carburetted hydrogen) at a red heat, the iron is carbonized and transformed into cast iron, of a grey color, very malleable, and equal to the best specimens produced by charcoal. But if the same gas be brought into contact with nitrogenized iron (nitride of iron), then, instead of cast iron, steel is produced, the good or bad quality of which entirely depends on the quantity of nitrogen previously combined with the iron; if that quantity is sufficient, the result is steel of the finest grain. If, instead of previously nitrogenizing and afterwards carbonizing the metal, a mixture of ammonia and illuminating gas be brought into contact with common iron at a red heat, it then at once absorbs nitrogen from the ammonia, and carbon from the carburetted hydrogen, and steel is obtained of a quality corresponding to the relative proportion of the two gases. Here, therefore, the process of cementation, instead of being effected by charcoal, is accomplished by a gas proceeding from pit-coal. If, conversely, steel be heated in an atmosphere of hydrogen, it loses its nitrogen, and ammonia is produced. Hence, M. Frémy concludes that steel is not a simple carburet, but nitro-carburetted iron; and this is true, not only of steel produced in laboratories, but of the common market article. In the subsequent sitting, M. Caron, well known for his endeavors to produce good steel by the action of cyanides (combinations of cyanogen, a compound of carbon and nitrogen with other elements), made some remarks tending to show that M. Frémy was not the first to have made the discovery, but M. Frémy, in reply, distinctly claimed the priority as regarded the fact that nitrogen is an indispensable ingredient of steel.

Movement of Sea and Lake Water.

From the Lond. Engineer No. 279.

The fact that the movement of sea and lake water is confined to the surface is proved by the circumstance that while the inclination of sand (where the bottom, near the shore, is composed of that material), may be 7 horizontal to 1 perpendicular within the range of the tides and waves, it often stands at only 2 to 1, a short distance below, or at the natural slope of sand in still water. This is the case on the shore of the Lake of Geneva, near Vevay, and a similar result was observed at Cherbourg, with respect to the small materials thrown into the sea for the formation of the breakwater and which took a slope, below low water, of 1 to 1.

The co-efficient of friction of leather belts on wooden pulleys has been found to be ·47 of the pressure, and on turned cast iron pulleys ·28 of the pressure.

AMERICAN PATENTS.

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Corn Planters, .	Aaron Colton, .	Attica,	"	28
——— .	H. J. Howe, .	Onarga,	Ill.	14
—— Shellers, .	Bundy & Edgerson, .	Hyde Park,	Vt.	14
Cotton Press, .	W. P. Craig, .	Newport,	Ky.	7
Cultivators, .	Cone & Potter, .	Oneida,	Ill.	28
——— .	Ira Cooper, .	Saybrook,	Ohio,	14
——— .	G. W. Hildreth, .	Lockport,	N. Y.	21
——— .	Mumford & Wilson,	Clarksburgh,	Ohio,	28
——— .	Joseph Vowles, .	New Hudson,	Mich.	21
——— .	W. S. Weir, Jr.,	Monmouth,	Ill.	28
Distillation,—Method of .	Van Buren Ryerson,	City of	N. Y.	7
Drawing Frames,—Stop Motion	H. G. Williams,	Warren,	R. I.	21
Dust Pan, .	G. H. Horstman, .	Philadelphia,	Penna.	21

Electric Machine,—Frictional	Robert Cornelius,	Philadelphia,	Penna.	21
Electrophorus, .	" .	"	"	21
Elevators, .	Otis Tufts, .	Boston,	Mass.	28
Erasers, .	James M. Hicks, .	"	"	14
Field Bucket, .	George Wood, .	Strasburg,	Penna.	14
Filter,—Portable .	H. A. Hall, .	Boston,	Mass.	21
Fire Arms, .	Albert V. Hill, .	Carrollton,	N. Y.	28
——— (2 patents),	J. H. Merrill, .	Baltimore,	Md.	28
———,—Magazine	Lorenzo Sibert, .	Mt. Solon,	Va.	14
———,—Revolving .	C. R. Alsop, .	Middletown,	Conn.	14
—— Extinguish. appar.,—Ship's	J. L. Stuart, .	City of	N. Y.	21
—— Place Heater, .	F. L. Hedenberg, .	"	"	21
—— Places, .	Gauson & Coit, .	Buffalo,	"	14
Flour,—Cooling and Drying	Park & Staats, .	Somerville,	N. J.	28
Furnaces,—Steam Boiler	J. R. Robinson, .	Boston,	Mass.	14
Gaiters,—Congress .	H. S. Holmes, .	Lynn,	Mass.	14
Gas Appar.,—Portable Water	Charles Harasythy,	San Francisco,	Cal.	21
—— Regulators, .	Thomas Powers, .	Philadelphia,	Penna.	14
Gates,—Approach Opening	R. Brinkerhoff, .	Mansfield,	Ohio,	28
Grain Separators, .	Charles B. Martin, .	Fond du Lac,	Wis.	28
——— .	J. A. Scott, .	Rochester,	N. Y.	28
Grinding,—Making Maize Fit for	S. P. McCroskey, .	Monroe,	Iowa,	28
Guano,—Sowing .	S. B. Black, .	Harrisburg,	Penna.	28
Harvesters, .	Ira Jewell, .	Wheaton,	Ill.	21
——— .	Frederick Landon,	Brockport,	N. Y.	28
——— .	J. S. Marsh, .	Lewisburg,	Penna.	21
——— .	James Pine, .	Troy,	N. Y.	7
——— .	C. P. Wing, .	Fayetteville,	"	28
———,—Clover	Frederick Decker,	Ostrander,	Ohio,	28
———,—Rakes for .	James Pine, .	Troy,	N. Y.	7
———,—Raking Attach.	A. B. Smith, .	Clinton,	Penna.	14
Hat Bodies,—Forming .	G. and C. Beatty, .	Norwalk,	Conn.	21
Hay,—Turning and Spreading	E. W. Bullard, .	Barre,	Mass.	21
Heating Apparatus, .	Ambrose Kohler, .	Boston,	"	28
Hoes,—Manufacture of	Walter Baker, .	W. Winstead,	Conn.	21
——,—Handles to .	W. T. Clement, .	Northampton,	Mass.	14
Honeycomb,—Artificial	Samuel Wagner,	York,	Penna.	7
Hook for Nautical Use,—Detach.	John Brooke, .	U. S. Navy,		28
Horse shoes,—Calks for	J. H. Jennings, .	New Bedford,	Mass.	21
Hose Pipes,—Valves for .	John M. deBolle, .	Philadelphia,	Penna.	28
Hydrants, .	Joseph Neumann,	"	"	14
Iron Buildings,—Constructing	S. J. Seely, .	Brooklyn,	N. Y.	7
—— Ore,—Furnaces for Smelt'g	Patrick Kerr, .	NewBethlehem,	Penna.	28
——,—Manufacture of Sheet	W. D. Wood, .	Wilmington,	Del.	14
—— Vessels,—Construction of	S. J. Seely, .	Brooklyn,	N. Y.	21
Irrigating Streets, .	J. P. Ellicott, .	Washington,	D. C.	14
Journal Boxes, .	D. H. Dotterer, .	Memphis,	Tenn.	7
Knitting Machines, .	Joseph Dalton, .	Brooklyn,	N. Y.	7
———	S. W. Howland,	Adams,	Mass.	14
Lamps, .	W. Freeman, .	Mt. Carmel,	Conn.	21
——— .	Frederick Heidrich,	Philadelphia,	Penna.	7
——— .	Walter Hunt, .	City of	N. Y.	21
Latch Bolts, .	John Adt, .	Waterbury,	Conn.	14
———,—Thumb .	John Range, .	Meriden,	"	14
Locks, .	Moses Ducharme,	Cohoes,	N. Y.	14
——— .	J. J. Hirsbuhl, .	Louisville,	Ky.	14
——— (2 patents,)	Linus Yale, Jr.,	Philadelphia,	Penna.	14
Locomotion,—Apparatus for	Elisha Matteson, .	Brooklyn,	N. Y.	28

Looms,	Graichen & Hoffman,	Clinton,	Mass.	7
———	Alexander Frey,	City of	N. Y.	7
———,—Let-off Motion for	Renssalaer Reynolds,	Stockport,	"	21
Man-power,—Application of	T. W. Hoskings,	Detroit,	Mich.	21
Milk Can,	Philip Teets,	City of	N. Y.	28
Milking Cows,	M. L. Baker,	Milford,	"	21
——— ———,—Device for	W. D. Nichols,	Davenport,	Iowa,	21
Mining Picks, &c.,—Making	Elisha Hughes,	McCartysville,	Cal.	7
Mowing Machines,	Henry Fisher,	Alliance,	Ohio,	7
Nail Machine,	E. G. Hall,	City of	N. Y.	7
Ordnance,	T. J. Mayall,	Roxbury,	Mass.	21
————,—Projectile for Rifled	B. B. Hotchkiss,	Sharon,	Conn.	14
————,—Vent-stoppers of	J. J. Hirschbuhl,	Louisville,	Ky.	28
Paint Cans,	J. F. Drummond,	City of	N. Y.	21
Photographic Albums,	Anthony & Phœbus,	"	"	28
———————	F. R. Grumel,	Geneva,	Switz.	14
Pianoforte Actions (2 patents),	Henry Steinway, Jr.,	City of	N. Y.	21
Picker Motion,	Wm. Nugent,	Chicopee,	Mass.	14
Pipe,—Casting	Samuel Fulton,	Conshohocken,	Penna.	21
Pipes,—Hydraulic Cement	Henry Knight,	Jersey City,	N. J.	14
Platforms,—Extension	Andrew Morse,	Portland,	Me.	7
Ploughs,	Thomas Patterson,	Rush,	Ill.	14
————,—Steam	Shotwell & Hicks,	Ottawa,	"	28
Portfolios for Music, &c.,	J. C. Koch,	City of	N. Y.	21
Pressure Indicator,—Hydrostatic	J. E. Wootten,	Philadelphia,	Penna.	14
Printing Presses,	G. R. Dean,	Mayville,	N. Y.	7
Puddling & Refining Furnaces,	S. M. Fales,	Baltimore,	Md.	14
Pumps,	H. G. Crowell,	Roxbury,	Mass.	21
———	J. M. May,	Janesville,	Wis.	7
———	W. E. Watters,	East Bend,	Ky.	7
———,—Rotary	Jones & Rider,	City of	N. Y.	21
Punch'g & Perforat. Paper, &c.,	G. C. Howard,	Philadelphia,	Penna.	21
Railroad Cars,—Running Gear of	Sebre Howard,	Elyria,	Ohio,	28
Railroads,—City	W. C. Grimes,	Philadelphia,	Penna.	14
Railways,—Permanent	Robert Watson,	Chatham,	Ill.	14
Rain Gutters,—Beading	Wm. H. Henderson,	Franklin,	Ind.	28
Rakes,—Horse	Samuel Mowry,	Whomelsdorf,	Penna.	14
Roofing,—Mastic Composit. for	C. C. Hoff,	Poughkeepsie,	N. Y.	14
——— with Slate,—Mode of	J. S. Sammons,	City of	"	21
Sad Iron,	Wm. McClure,	Peebles,	Penna.	14
Saw Mills,	Wm. M. Ferry, Jr.,	Ferrysburg,	Mich.	28
Sawing Machines,—Feeding	Jesse Gilman,	S. Merrimack,	N. H.	28
Seed Drills,	J. S. Marsh,	Lewisburg,	Penna.	14
————	Jacob Strayer,	Miamisburg,	Ohio,	14
Seeding Machines,	H. R. Stover,	Lancaster,	Penna.	14
Sewer Inlets,	Strickland Kneass,	Philadelphia,	"	21
Sewing Machines,	Samuel Comfort, Jr.,	Morrisville,	"	7
——————	Lewis Cooper,	Philadelphia,	"	28
——————	Jones & Hanghain,	Brooklyn,	N. Y.	14
——————	J. P. Sherwood,	Fort Edward,	"	14
——————	L. H. Smith,	Salem,	N. J.	21
——————	J. W. Stoakes,	Milan,	Ohio,	28
——————	M. G. Wilder,	Meriden,	Conn.	14
Shafting,—Hangers for	M. H. Mansfield,	Ashland,	Ohio,	14
Signal Lanterns,—Railroad	N. A. Menaar,	Buffalo,	N. Y.	21
Skates,	Goodyear & Sprague,	Binghamton,	"	21
———	N. C. Sandford,	Meriden,	Conn.	28
Sled Brake,	A. S. Clark,	Dryden,	N. Y.	21
Smelting & Refining Furnaces,	S. M. Fales,	Baltimore,	Md.	14

Springs,—Making Upholstery	C. A. Young, .	Providence,	R. I.	21
Steam Boilers,—low water alarm	W. H. Miller, .	Philadelphia,	Penna.	14
——— Cock, .	Thomas Sanford, .	Claremont,	N. H.	14
Steering Apparatus,	J. McCausland & others,	Rondout,	N. Y.	14
——————— .	Richard F. Joynes, .	Bristol,	R. I.	28
Stoves, .	Treadwell & Hailes,	Albany,	N. Y.	7
Sugar,—Breaking .	Joseph Forrest, .	City of	"	14
Telegraphic Apparatus,	G. M. Phelps, .	Williamsburg,	N. Y.	28
Thimble Boxes,—Casting	J. G. Holt, .	Chicago,	Ill.	7
——— Skeins,—Patterns for	E. F. Hurlbut, .	"	"	21
Thread,—Winding .	J. A. Bradshaw, .	Lowell,	Mass.	28
Threshing Machines,	S. E. Oviatt, .	Richfield,	Ohio,	14
Time Tell-tale, .	Henry Maule, .	Philadelphia,	Penna.	14
Tin Foils,—Manufacture of	J. J. Crooke, .	City of	N. Y.	21
Tire,—Upsetting .	Benjamin Upton, .	Elyria,	Ohio,	21
Tops,—Children's Flying	Henry Benton, .	Guilford,	Conn.	14
Traps,—Animal .	John Quigley, .	Winona,	Minn.	28
Trusses, .	Gordon & Dunn,	Albany,	N. Y.	7
Valves, .	Daniel Minthurn, .	Beverly,	Mass.	28
Vapors,—Disseminat. Medicated	J. W. Smith, .	Iowa Point,	Kansas,	21
Vegetable Cutter, .	Earl Guyer, .	Wolcott,	Vt.	7
Washing Machine,	John D. Cochran,	Milford,	N. H.	28
—————— .	J. and A. H. Doty, .	West Falls,	N. Y.	28
——————	C. O. Luce, .	Brandon,	Vt.	14
—————— .	L. L. Miller, .	Jersey Shore,	Penna.	14
——————	J. S. Peaslee, .	Providence,	R. I.	7
—————— .	Stephens & Buell, .	City of	N. Y.	28
——————	J. N. Wilson, .	Mt Bethel,	Penna.	14
Water Elevators, .	C. Bixler, .	Rogersville,	Ohio,	21
————— .	George Murray,	Cleveland,	"	14
——— Wheels, .	J. B. Caldwell, .	Chambersb'h,	Penna.	28
Weather Strips,—Adjustable	O. B. Scofield, .	E. Stoughton,	Mass.	28
Weighing Sacks, .	Henry Winter, .	Hackney,	Engl'd,	14
Wheels,—Annealing Car	A. L. Mowry, .	Cincinnati,	Ohio,	7
Wheelwright's Machine, .	N. T. Edson, .	New Orleans,	La.	14
Window Shade, .	J. W. Ogle, .	Concord,	Ill.	28
Windlasses, .	Edwards & Horner, .	City of	N. Y.	7
Wind Wheel, .	Jacob Maag, .	Milwaukie,	Wis.	28
Wool, &c.,—Machines for Drying	Benjamin James, .	Worcester,	Mass.	28
Wrenches, .	G. B. Phillips, .	Newark,	N. J.	28
Zinc for a Paint,—Oxide of	Charles Titterton, .	Rohampton,	Gr. Brit.	14

EXTENSIONS.

Screws,—Cutting .	P. W. Gates, .	Chicago,	Ill.	14
Wheels for Railroad Carriages,	A. Atwood (3 patents),	Troy,	N. Y.	14

RE-ISSUES.

Cartridge Cases,—Metallic	Edward Maynard, .	Washington,	D. C.	28
Cheese,—Manufacture of	Redington & McCluer,	Fredonia,	N. Y.	21
Furnaces,—Steam Boiler	J. R. Robinson, .	Boston,	Mass.	14
Harvesters (4 patents),	G. M. Selden, .	Troy,	N. Y.	7
Horse Power, .	Brayley & Pitts, .	Buffalo,	"	14
Hose Coupling, .	Emerson Gaylord,	Chicopee,	Mass.	21
Kettles,—Making Brass .	F. J. Seymour, .	Waterbury,	Conn.	14
Planing Machines,—Wood	H. D. Stover, .	City of	N. Y.	21
Reaping Machines, .	W. H. Seymour & others,	Brockport,	"	7
Ship Building, .	R. F. Loper, .	Philadelphia,	Penna.	7
Steam Hammer, .	R. R. Taylor, .	Reading,	"	21
Water Wheels, .	H. G. Nelson, .	Mexico,	N. Y.	21
Winch,—Direct & Counter Mot.	Charles Perly, .	City of	"	21

DESIGNS.				
Carpet (11 cases),	H. G. Thompson,	City of	N. Y.	7
Curtain Loops, .	Edward Maynard, .	Brooklyn,	"	28
Hats, .	J. J. Morrisett, .	City of	"	28
—— .	S. R. Hawley, .	"	"	28
Pumps, .	Miles Greenwood,	Cincinnati,	Ohio,	28
Skirt,—Balmoral .	C. M. Cooke, .	Waterloo,	N. Y.	28
Stoves, .	M. C. Burleigh, .	Somersworth,	N. H.	28
—— .	Smith & Brown, .	Philadelphia,	Penna.	28
Stove, .	S. W. Gibbs, .	Albany,	N. Y.	7
——,—Cook .	N. S. Vedder, .	Troy,	"	28
Stoves,—Cooking .	Smith & Brown,	Philadelphia,	Penna.	14
Stove,———— .	S. W. Gibbs, .	Albany,	N. Y.	7
Stoves,———— .	C. W. Palmer, .	Troy,	"	7
Stove,—Parlor .	S. W. Gibbs, .	Albany,	"	7
———— .	"	"	"	28
Tea-pot, .	Hiram Young, .	City of	"	7
Trade Mark, .	A. F. Johnson, .	Boston,	Mass.	28
————,—Label or .	I. D. Brewer, .	Cambridge,	"	28

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, July 18, 1861.

John Agnew, Vice President, in the chair.
Frederick Fraley, Corresponding Secretary. } Present.
Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were presented by the Zoological Society, London; la Société Industrielle de Mulhouse, and l'Ecole des Mines, Paris, France; de Niederosterreichischen Gewerbe-Vereines, Vienna, Austria; Messrs. F. H. Storer and Charles W. Elliot, Boston, Mass.; and Dr. S. S. Garrigues and Prof. J. F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of June was read.

The Board of Managers and Standing Committees reported their minutes.

Two candidates for membership in the Institute were proposed.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.

Rain and Clouds.—In former articles* I have given somewhat minutely my observations on the atmospheric pressure, and on the temperature of Philadelphia, for a period of nine and a half years, up to the end of December, 1860. The following table shows the quantity of rain and melted snow that fell during the same period.

* See Journ. Frank. Inst., present series, vol. xli., pages 64 and 351.

TABLE I.—*Amount of Rain and melted snow, in inches, which fell at Philadelphia, from July*, 1851, *till December*, 1860, *inclusive.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
January,		2·010	1·840	2·320	2·601	3·368	2·989	2·686	5·230	3·351	2·933
February,		2·710	4·440	4·200	2 480	1·128	0·921	2·393	3·569	2·724	2·729
March,		4·270	2·460	1·625	1 979	2·039	1 773	1·124	6·503	1·323	2·566
April,		6·440	3·880	8·145	2·148	3 149	6·932	4·681	5·668	3·646	4·965
May,		3·040	5·170	7·299	3·033	2·334	6·043	5·308	1·946	3·589	4 196
June,		4·500	1·050	3·441	8·008	1·677	7·426	4·205	5·229	3·706	4·360
July,	4·360	4·060	8·630	3·837	6·594	1·127	3·373	1·454	3·915	0·851	3·820
August,	3·420	4·400	3·080	0 918	3·237	5·186	8·039	5·157	4·447	9·260	4·714
September,	3·600	1·290	4·460	4·883	4·129	5·702	1·132	1·589	7·779	2·907	3·747
October,	3·038	2·250	3·470	1·918	3·416	1·303	2·742	1·778	3·210	4·685	2 781
November,	3·410	6 050	2·320	3·460	2·022	2·886	1·575	5·225	3·796	6·057	3·680
December,	1·880	5·180	2·165	3·185	5 006	3·619	5·503	5·459	3·460	3·301	3·876
Annual totals,		46·200	42·965	45·231	44·653	32·518	48·448	41·059	54·752	45·400	44·692
Winter,		6·600	11·460	8 685	8·266	9·502	7·529	10·582	14·258	9·535	9·602
Spring,		13·750	11·510	17·069	7·160	7·522	14·748	11·113	14·117	8·558	11·727
Summer,		12 960	12·760	8·196	17 839	7·990	18·838	10·816	13·591	13·817	12·979
Autumn,	10·048	9·590	10·250	10·261	9·567	9·891	5·449	8·592	14·785	13·649	10·208

Table II. contains the number of days on which rain or snow fell in such quantity as could be measured.

TABLE II.—*Number of days in each month from July*, 1851, *till December*, 1860, *on which rain or snow fell, at Philadelphia.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
January,		9	5	11	11	11	12	9	10	8	9·6
February,		12	12	10	7	7	8	10	14	8	9·8
March,		14	11	10	8	11	9	8	14	8	10 3
April,		15	12	14	9	14	14	15	13	15	13·4
May,		10	15	15	8	12	12	18	11	19	13·3
June,		12	6	9	17	10	17	10	12	10	11·4
July,	11	9	14	9	9	9	12	10	11	10	10·4
August,	8	13	11	9	11	9	10	10	8	13	10·2
September,	10	6	8	6	11	7	9	6	11	7	8·1
October,	10	7	7	9	11	6	8	9	7	13	8·7
November,	11	15	11	7	7	9	11	12	8	12	10·3
December,	10	15	8	11	13	6	12	14	10	8	10·7
Annual totals,		137	120	120	122	111	134	131	129	131	126·1
Winter,		31	32	29	29	31	26	31	38	26	30·3
Spring,		39	38	39	25	37	35	41	38	42	37·1
Summer,		34	31	27	37	28	39	30	31	33	32·2
Autumn,	31	28	26	22	29	22	28	27	26	32	27·1

The amount of sky covered by clouds is estimated, as near as may be, at the time of each observation, and entered on the record as so many tenths covered. In the following tables, these amounts have been changed into hundredths, and entitled so much per cent. covered. If the sky is entirely covered, it is marked 100 per cent., if half covered, 50, &c. Table III. shows the comparative quantity of sky covered at the different hours of observation. It will be seen, as might be expected, that as the temperature of the day decreases, the quantity of moisture condensed in the form of clouds also decreases.

TABLE III.—*Amount of sky covered with clouds at* 7 *A. M.*, 2 *P. M.*, *and* 9 *P. M.*, *as determined by estimated observations, extending from July*, 1851, *till December*, 1860, *at Philadelphia.*

Months.	7 A. M.	2 P. M.	9 P. M.	Monthly Mean.
	Per ct.	Per ct.	Per ct.	Per ct.
January, . .	61	62	45	56
February, .	61	59	43	54
March, . .	58	59	41	53
April, . .	64	65	53	61
May, . .	60	60	48	56
June, . .	57	60	44	53
July, . .	56	56	39	51
August, .	54	59	41	51
September, .	54	50	34	46
October, .	54	54	39	49
November, .	60	59	52	57
December, .	65	64	48	59
Hourly Means, .	58·7	59·0	43·9	53·9
Winter, .	63	61	45	56
Spring, . .	61	62	47	57
Summer, .	56	59	41	52
Autumn, . .	57	54	41	51

The average amount of cloudiness for a day is obtained by taking the mean of the estimated amount for the three observations; and for a month by finding the average of the daily means. The comparative cloudiness of each month of the year, obtained in this manner, is shown in the fourth table.

TABLE IV.—*Showing the comparative cloudiness of each month and season, from July*, 1851, *till December*, 1860, *inclusive, at Philadelphia.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
January,		45	50	63	63	54	53	58	57	60	56
February,		45	61	51	59	58	47	56	61	49	54
March,		57	53	51	67	48	52	41	55	52	53
April,		62	63	68	60	59	56	64	60	54	61
May,		46	52	48	60	57	55	70	49	69	56
June,		41	44	51	66	58	64	51	56	50	53
July,	47	41	56	48	60	49	63	43	48	50	51
August,	43	57	51	50	58	50	51	55	49	53	51
September,	38	31	45	53	47	45	54	35	61	49	46
October,	36	47	39	44	54	47	66	49	54	59	49
November,	56	58	66	56	66	48	47	66	51	58	57
December,	53	63	48	61	67	49	56	70	65	60	59
Annual means,		49	52	54	60	52	55	55	55	55	54
Winter,		48	58	54	61	60	50	57	63	58	56
Spring,		55	56	56	62	55	54	58	55	58	57
Summer,		46	50	50	62	52	59	49	51	51	52
Autumn,	43	45	50	51	56	47	56	50	55	55	51

June.—The mean temperature of the month of June differed less than half a degree from the mean temperature of the month for the last ten years; it was, however, higher by a degree and a half than that of June last year.

The warmest day of the month was the 23d, of which the mean temperature was 82·8°. The thermometer was highest (91°), however, on the 15th, of which the mean temperature was 82·3.

The coldest day was 6th, of which the mean temperature was 55°. The thermometer indicated the lowest temperature (51°) on the same day.

The greatest daily oscillation, or change of temperature in the course of one day, was 29° on the 10th. The least daily oscillation was 8° on the 6th, when rain fell nearly all day. The average oscillation for the month (18·55°) was half a degree less than for June, 1860, but two degrees greater than the average for June for ten years past.

The greatest daily range of temperature—that is, the greatest mean difference of temperature between two successive days—was $12\frac{1}{2}$° between the 16th and 17th; the least was $\frac{8}{10}$ of a degree between the 13th and 14th. The average daily range for the month was 5·29°, which was one degree greater than for June last year, and about half a degree greater than the average for the month for ten years.

The atmospheric pressure was greatest (30·062 inches) on the morning of the 1st, and least (29·529 inches) on the evening of the 21st, but the mean daily pressure was least (29·563) on the 16th of the month and greatest (30·004) on the 1st. The mean pressure at 7 A.M. and 2 P.M. was about two-hundredths of an inch greater than for the same hours for June of last year, and about four-hundredths of an inch less than the average for ten years; but at 9 P.M. it was about six-hundredths of an inch less than the average and nearly one-hundredth of an inch less than for the same hour of June, 1860. This month presents the only instance that I have on record of the average atmospheric pressure, for a whole month, being less at 9 P.M. than at 2 P.M. According to analogy, the mean pressure at 9 P.M., for the month of June last, should have been 29·759 ins., just two-hundredths of an inch more than it actually was.

The greatest mean daily range of pressure for the month was 0·243 of an inch, and occurred between the 14th and 15th; the least was 0·023 of an inch between the 18th and 19th; and the average for the whole month was 0·104 of an inch, which was seven-thousandths of an inch greater than usual.

The force of vapor was greater than for June of last year, but less than the average for ten years.

The relative humidity was less at 7 A.M. and greater at 2 P.M. and 9 P.M. than it was during June, 1860. It was considerably less than the average at 7 A.M., a little less at 2 P.M., and just the same as the average at 9 P.M. for the last ten years. The anomaly in this case appears to correspond in some degree with that of the pressure of the atmosphere.

Rain fell on 15 days of the month to the aggregate depth of 4·485 inches. More than half of this amount, or 2·35 inches, fell in nineteen hours, beginning at 8 P. M. on the 5th, and ending at 3 P. M. on the 6th of the month.

Five thunder storms occurred in the course of the month, namely, on the afternoon of the 8th, when rain mingled with hail fell, on the morning of the 11th, the afternoon of the 12th, the night of the 15th, and the evening of the 26th. None of these storms were very violent about Philadelphia. That on the night of the 15th, seems to have extended as far north and east as Plymouth County, Mass., where it was felt on the 16th, accompanied by hail and by a very strong wind. At Branchville, N. J., about 8 o'clock on the morning of the 16th, hail fell as large as hens' eggs, the steeple of the church was blown down, houses unroofed, and trees uprooted.

The sky was entirely clear or free from clouds on two days, and completely covered with clouds on two days of the month at the hours of observation.

A Comparison of some of the Meteorological Phenomena of June, 1861, *with those of June,* 1860, *and of the same month for ten years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	June, 1861.	June, 1860.	June, 10 years.
Thermometer.—Highest,	91°	93°	98°
" Lowest,	51	52	42
" Daily oscillation,	18·55	18·90	16·25
" Mean daily range,	5·29	4·20	4·70
" Means at 7 A. M.,	69·30	67·70	69·26
" " 2 P. M.,	79·27	78·38	79·29
" " 9 P. M.,	70·83	69·05	71·94
" " for the month,	73·13	71·71	73·50
Barometer.—Highest,	30·062 in.	30·123 in.	30·281 in.
" Lowest,	29·528	29·243	29·182
" Mean daily range,	·104	·088	·097
" Means at 7 A. M.,	29·783	29·757	29·821
" " 2 P. M.,	29·742	29·719	29 786
" " 9 P. M.,	29·739	29·745	29·796
" " for the month,	29·754	29·740	29·801
Force of Vapor.—Means at 7 A. M.,	·475 in.	·467 in.	·522 in.
" " " 2 P. M.,	·512	·464	·546
" " " 9 P. M.,	·530	·480	·559
Relative Humidity.—Means at 7 A. M.,	66 per ct.	68 per ct.	73 per ct.
" " " 2 P. M.,	52	48	54
" " " 9 P. M.,	70	67	70
Rain, amount in inches,	4·485 in.	3·706 in.	4·373 in.
No. of days on which rain fell,	15	10	11·8
Prevailing winds,	s 81°52′w ·176	n 67°23′w ·236	s76°8′w ·248

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CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Bridge over the Theiss, and Tubular Foundations. By M. CEZANNE, Engineer des Ponts et Chaussées. Translated by J. BENNETT.

(Continued from page 90.)

PART THIRD—(*Continued.*)

Air Pumps.—The air pumps used at Szegedin were composed of two vertical cylinders a short distance apart. In the upper cylinder, which was 8·66 ins. diameter, the steam worked a piston having the same rod with the piston of the pump, which was 11·8 inches in diameter.

The stroke of the piston was 7·87 ins.; the number of strokes per minute was from 100 to 120.

These machines were double-acting, with a variable expansion and a free escapement. They were from 10 to 12 horse-powers and weighed 4840 pounds; the steam was furnished by old locomotives planted upon a pontoon, coupled with a similar pontoon, bearing the coal and watchman's box.

The apparatus thus being installed, the bell loaded with the counterpoise, designed to equilibrate the interior pressure, the column being inserted between its guides, and the inner doors of the air chamber being shut, with one valve at least open, the pumps were set at work.

At first there was much leakage through the air chambers, but the pressure increasing closed the doors or valves against their linings, and the joints became air-tight. At Szegedin, it required one hour's work of one pump to obtain one atmosphere of pressure. When the interior pressure was sufficient, the interior cock of the syphon was opened, and the water rose to its delivery. By a little contrivance the water could be exhausted at a less pressure than required by the usual hydrostatic laws; by slackening a joint in the lower part of the interior syphon, a little air was admitted, and the mixture of air and water being lighter than water, was raised before attaining the pressure required for pure water.

The diameter of the syphon was 2·36 ins.; the time required to draw off 705·7 cubic feet of water was, in good working condition, one hour.

When the water was exhausted, the men went in, and the work began. A gang was usually composed of nine men:

One overseer, sometimes inside, sometimes outside.

Two miners at the bottom of the column.

Four hands at the interior windlass (placed upon the platform), upon which was rolled a chain, with a full bucket ascending at one end, and an empty bucket descending at the other.

Two men upon the reservoir, to draw up the full buckets placed in the air chamber by the men within. This operation was performed by means of a common wood windlass placed upon the counterpoise.

There were besides these, a stoker and his assistant, and one to take charge of the manometer.

The valve being opened, the men and the buckets were passed into the air chamber. The men at the exterior windlass made fast the hook of their chain to the ring or handle of the valve, and raised it to press against the india-rubber lining.

The cocks being suitably worked by the person who enters or by the men outside, if a bucket is to be passed, the air blows in the chamber; the valve closes of itself, and the lower door opens.

Physiological Effects of the Compressed Air.—This is the proper place to give some details as to the physiological effects of the compressed air. It may be regarded in three phases—the entrance, the remaining, and the departure.

When cooped in the air chamber to allow the closing of the upper valve, a cock is opened for the entrance of the air, one is immediately seized with a violent buzzing in the ears, attended with pain, whose intensity varies with individuals. The air is of an oppressive heat, with a strong smell of caoutchouc and sweat. There is utter darkness. Care must be taken to avoid opening the cock for the entrance of the air, before making sure that the outlet orifice is well closed. If this precaution is neglected, one is caught in a violent current of air, which immediately causes severe neuralgic pains in the teeth, temples, and ears.

When no regard is paid to favoring the ears, and the cock is opened briskly, as is usually done by the workmen, the pressure is established

in less than a minute, and the lower door opens. On reaching the platform at the side of the windlass hands, the air is very damp and heated by compression; this space resembles a drying room, and at Szegedin the thermometer rose above 140°.

To reach the miners, one is lowered in a bucket; and in proportion to the descent, the air becomes more fresh and pure. At the bottom of the column, when the water is completely cleared, and the bottom dry, the position is supportable; still the excessive comfort spoken of by an author* is not experienced, but a sensation of relief similar to that succeeding a painful operation.

The passage through the air chamber is quite disagreeable; some persons, however, are so accustomed to it as to think nothing of it; but there are workmen who, after many weeks perseverance, become discouraged, and decline the high pay tendered as a bonus for their sufferings.

The position at the bottom of the tube, under a pressure of 3 atmospheres, may be prolonged many hours without inconvenience; the tone of the voice is somewhat changed, the respiration increased as by a rapid walk; a dry cigar kept in motion is consumed in a flame; the wax-lights burn rapidly, but with a smoky flame, depositing lampblack on all sides; it quickly blackens the nostrils, the bottom of the throat, and penetrates the lungs; smut is blown from the nose, and spit from the mouth, for many days after a long stay in the tubes. These discomforts are more apparent with oil lamps.

The time of departure, though but little painful for the majority of individuals, is the most dangerous for the workmen. As soon as the compressed air escapes from the air chamber, the temperature lowers suddenly, the vapor condenses, and when the upper valve is opened, one issues surrounded by a cloud. At this moment blood sometimes flows from the nose and the throat; some persons experience violent neuralgias, but of short duration; others have tooth and headache for many days.

Most frequently the leaving is attended with no other sensation but that of a cold air douche, followed by a slight tension of the ears.

The men who usually work in the tubes look ill; but they persevere steadily, and up to pressures of 3 atmospheres we may be sure of finding as many workmen as are required for the working of the tubes.

There were at Szegedin some miners who had worked at the Quarantaine bridge at Lyons, and at the bridge at Macon, whose health was perfect. One died of paralysis of the lungs, but his habits were very irregular.

The fever, endemic along the borders of the Theiss, has not attacked the miners more than other workmen; in a sanatory view it seemed that they might be rather classed by nationality; the Italians and the Germans were the most sickly, the French and Hungarians were in better health.

A gang of nine men worked six hours and rested six hours; the work progressed night and day.

* Revue des Deux-Mondes, 1st Nov., 1857, p. 207.

Fifteen buckets of clay or sand were taken out per hour; the contents of a bucket being 2·47 cubic feet.

The slowest operation was the raising of the buckets, and some interest was felt in expediting the work; at the bridge of Bordeaux, this was effected by making an opening in the cylindrical sides, midway of the column, to which was fitted a special air chamber, through which the excavation was emptied.

At Szegedin, the ends of the chain bearing the buckets, on leaving the windlass, passed over a gibbet, M, fixed upon the plane part of the air chamber, and movable around a vertical axis. By this arrangement the bucket is raised to the level of the air chamber, in which it is deposited without effort if the vertical door is open.

Then this door is pushed to, the cock is turned, the door closes, the upper valve falls, and the men outside fasten their end of the chain in the handle of the bucket, raise it, and replace it by an empty bucket, which by a turn of the cock is put at the disposal of the men inside.

Sinking of the Columns.—When the excavation has reached the end of the tube, the miners leave, after taking up the lower branch of the syphon, and placing their tools upon the interior flooring; the column is adjusted in its guides, and the escape valves are opened briskly.

The effect then produced varies with the nature of the bottom, and in the same bottom with the plugging of the tube, the height of the water, and the load of the column, &c.

At the first trial of the sinkage of a column on the Theiss (the first pier) it lowered rapidly, carrying with it the guides, and there were fears of its swamping. It stopped after a descent of fourteen feet. Usually the descent varied from 3 ft. to 6·6 ft.; often, whatever the load upon the column, it remained insensible to the discharge of the air, and then started without apparent cause.

The interior pressure of the air equilibrates at the same time the outward pressure of the water and of the air, and the weight of the column, which would itself be lifted up were it not amply loaded. The moment the air escapes, the water enters violently at the bottom, bearing the earth with it, and the tube falls in proportion to the undermining thus made at its foot. The motion stops when the mass of water and sand let inside equilibrates the outward pressure, and when the friction of the tube is in equilibrium with its weight. The friction is very slight in sand and fine gravel, but enormous in clay. Now, as the latter is more difficult to undermine than the sand, we see that the effects of discharging the air must vary with the proportion of clay or sand in the bottom. When a column which has only gained a few inches under the action of many discharges of air, falls suddenly 1 or 2 yards, it is from the fact that having passed with difficulty through a clay bed, it then meets with a bed of sand more easily disturbed.

A column weighing 120 tons, having a depth of 19·7 feet, in a clay bottom, is stopped in the descent when there is a difference of 32·8 ft. between the levels of the internal and external water, and with only a slight interior tamping; while in the sand, a column weighing 40 tons, having a depth of 32·8 feet, and a tamping of 16·4 feet, falls of itself

if the rising of the water produces only a difference of 6·5 feet in the level.

In clay, the column adjoining that worked upon generally remains immovable during the ascent of the latter; in sand, it either settles or inclines. In clay, the columns have a slight tendency to deviate; in sand, they generally incline up stream, because on that side the river makes the first undermining.

From the above remarks it is seen how little control is had in arresting the columns at a desired plane, or in preserving a vertical direction. Each bottom has its inconveniences and its resources, and it becomes necessary to feel the way along by trial. The columns deviate most frequently in sand, but the deviations are most difficult to be righted in clay. The best bottoms are the gravel.

Means of Correction.—To right an inclined column, strong oblique shores abutting on scaffolds are applied to it. The head of the shores descends with the column, and drives it back on approaching the horizontal; the column inclining one side, it is pressed over the other side, and at each trial is made to approach the vertical.

When a column descends with an inclined direction, its foot moves horizontally; on this account some allowance must be made, either by increasing the counter-weight upon the side to be sunk, or in digging away the bottom more deeply on that side, so as to facilitate the undermining, and sometimes by placing strong oak wedges under the foot of the columns, and supporting them against a core of earth placed inside. The foot of the tube slides upon these wedges during the descent; but when the hold is considerable in the clay, it is difficult by these means to gain more than $1\frac{1}{2}$ to 2 inches. When the errors are very great, there is no remedy but to withdraw the column, which can be effected by the windlasses, after establishing an equilibrium with the internal pressure.

As the plane of the foundation is approached the discharge of the air is moderated, by leaving a tamping at the bottom of the tubes, by controlling the escape of the air, and by unloading the column; if the motion is more rapid than desirable, the pressure may be renewed, and the tube stopped by a forced working of the pumps. At Szegedin, water pumps were placed near the air chambers, and sometimes the column was filled to the outer level, lowering the pressure proportionally, the only way of assuring the immobility of the tube. It is remarkable that a bottom in which the tube sinks spontaneously, with the least difference between the inner and outer levels, presents so great resistance to compression when a hydrostatic equilibrium is established.

Columns of 100 tons weight have often been observed to be supported upon the foundation by a surface of 1·863 square yards, formed of the end and flanch of the tube. This would be 91 pounds per square inch.

Whatever precautions are taken for directing the columns, it is well to count upon deviations of 4 inches in every direction, and to reserve the means of correcting them. This is quite easy when the columns

support uprights only. The errors, measured in the plane of the head, are as a mean 4 inches in each direction, giving a slope of 0·005 with the vertical; they may reach the double of these figures, and depend upon many circumstances, but chiefly upon the nature of the bottom, and the stiffness of the scaffolding which guides the column.

The increased volume of earth due to the descent is quite variable; as a mean at the Theiss it was threefold; in other words, the cube of the excavated earth, measured by the number and capacity of the buckets, was three times greater than the total void dug out by the miners. In clay the increase is hardly appreciable.

In the common applications of tubular foundations, as soon as by reason of the last discharge of air the column has reached the desired depth, the pressure is renewed, the miners take away the pugging, leaving however a thickness of earth of three feet, to check the variations of water level which follow the variations of the manometer; the necessary materials of sand and water are passed to them through the air chamber, and a layer of cement from 2 to 3 ft. thick is commenced. Care is taken to leave in the middle of this layer a cylindrical hole from 8 to 12 inches diameter, which is only filled at the moment when they begin to lay on the beton. This hole allows the water to enter the pumps, in case of accident, without destroying the body of the cement.

At Szegedin, when a column was at its depth it was filled with water an appointed height, to avoid the spontaneous sinkage, and the pneumatic fixtures being taken away, special diving bells were then used.

It was only after the driving of the piles to the desired refusal, that the first available pneumatic apparatus was put up for syphoning the water, to cut away the piles in pieces of 3 ft. for their passage through the air chamber, and to finish the excavation.

Betonage of the Columns.—When a column is ready for the beton, some buckets of beton are lowered, which is laid with the trowel at the bottom of the column to form a cushion, and then all the miners retire upon the platform under the reservoir. A barrow-gang is organized to fill the air chamber with beton; as soon as it is full, notice is given for those inside to clear the way; the upper valve is closed and the lower door opened by manœuvring the cocks as usual; the beton then falls upon the platform and at the bottom of the column. The miners inside clear the chamber with scrapers, and close the lower door; the upper valve falls, and the chamber is again filled with beton.

Whenever an approach is made to the flanch, the miners level the beton and fill up its recesses.

When the height of the beton is half that of the exterior water, measured from the plane of the foundation, the pressure is stopped, the receiver raised, and the beton laid in open air; after this the beton is crowned with masonry and the superstructure is raised.

The following table gives the principal dates of work of the second pier of the Theiss bridge:

Character of Work.	Dates for the	
	Up-stream Column.	Down-stream Column.
Sinking of the column,	July 31, 1857.	August 4, 1857.
Pneumatic work—Commencement,	August 10, "	August 17, "
" " End,	August 31, "	September 6, "
Interior piling—Commencement,	October 25, "	October 9, "
" " End,	January 25, 1858.	January 8, 1858.
Betonage—Commencement,	March 10, "	March 6, "
" End,	March 13, "	March 8, "
Setting up the square bodies,	March 17, "	March 17, "

If the interior piling had not been required, the beton could have been introduced—

In the down-stream column, August 31, 1857.

In the up-stream column, September 6, 1857.

This operation for both columns would have been completed on the 15th of September; the entire pier would have been laid and prepared for the superstructure of the bridge in less than two months, with the use of but a single pneumatic apparatus. The interior piling and the severity of the winter of 1857–58, retarded the completion of the bridge several months, and yet the work was finished in two years after the settlement of the contract. This result could not have been attained with other systems of foundation, and the advantage of rapid execution has recommended the future use of tubular piers to all engineers.

The processes and apparatus above described have been applied to numerous works, and though convenient and sure, are yet susceptible of improvements. Many ingenious thoughts have become subjects for experiment or study upon some of the great European rivers, the Garonne, the Rhone, the Po, the Danube, the Vistula, &c. It is to be hoped that the authors of these works will make known the results.

We close this notice with some data relative to the net cost of the foundations of the Theiss bridge.

Net Cost of Tubular Foundations.—The cost depends upon the number of columns, their dimensions, the price of materials, &c. We shall consider only the expense of the pneumatic construction, in which we must distinguish the cost of the first establishment and that of manœuvring the apparatus.

An outfit for the Theiss bridge is comprised of the following parts:

A pneumatic reservoir, with its accessories, such as pipes, india-rubber linings, weighing 7000 kil., at 2 fr., ...	$2632·00
An air pump, weighing 1200 kil., at 4 frs., ...	902·40
Rough cast iron counter-weights, bought in England, 40,000 kil., at 10 centimes, ...	752·00
Besides these articles, representing about	$3534·40
The company furnished some old locomotives, answering for steam boilers, and some pontoons. For this part of the instalment we should reckon, as for special apparatus, ...	2105·60
The whole cost of the first establishment, amounting to . .	$5610·00

should be divided by the number of feet of the pneumatic piers, designed to be constructed with one outfit, either for one or many bridges.

This total does not include the planing or piercing machines, the loading cars, windlasses, tackle, &c.

The manœuvring of the apparatus is composed of the requisite loading for the instalment, and of the manœuvring proper.

The moving of the outfits from one pier to another cost as a mean at Szegedin, $56·40.

A similar moving from one column to another of the same pier cost $32·90.

An hour's working of the apparatus cost $1·99 distributed as follows:

	Frs.		Cts.
Workmanship—8 miners, at	0 35	=	52·64
1 miner, at	0 50	=	9 40
1 assistant fireman, at	0·25	=	4·70
1 watchman, at	0·25	=	4·70
Total of workmanship,	4·10	=	77·08
General expenses, one-third of workmanship,	1·37	=	25·75
Bonus for excavators,	0·40	=	7 52
Fuel and different furnishings,	4 75	=	89·30
Total,	10·	=	$1·99

The total pneumatic construction of 318 feet, divided between six piers, and so twelve columns of the Theiss bridge required

10 loadings, at 300 frs.,	$ 564·00
21 movings, at 175 frs.,	690 90
3451 hours, at 10·60 frs.,	6877·04
Total,	$8131·94
Or the mean cost per running foot of pneumatic construction,	$25·57

This price does not include the furnishing, the transportation, and maintenance of the apparatus, the jointing, the sinking of the columns, the carpenter's work in directing or repairing.

The introduction of 31,855 cubic feet of beton through the pneumatic bell, required 253 hours at $1·99, which may be regarded as the mean cost of the betonage under the bell, including leveling and interior damages, but exclusive of the carriage of the beton from its place of manufacture to the air chamber into which it was dumped directly from the barrow; this may be set at 56 cents.

The above cost of the moving of apparatus and of the running foot of pneumatic construction may be considered as proportional, all else being equal, to the cube of the diameter of the columns, and the depth required below the water.

NOTES.

Note A.—*Upon some effects of the variations of temperature observed at the Theiss Bridge.*

In preparing the plan, it was admitted, that the variations of temperature would, as is usual for arch bridges, have no other effect but to raise or lower the summit of the arches, that the distance between the piers would remain constant, that the efforts

produced by the changes of form arising from changes of temperature would attain their maximum in the upper chord, during the low temperatures, and that there was no occasion for solicitude, as might be inferred from a very simple calculation. The fastening of the upper chord upon the square bodies, being one of the conditions of the stability of the piers, it was proposed to complete it by mooring the ends of these upper chords behind the abutments.

In reality the rolled iron trusses are so rigid in the vertical plane, that they manifest a tendency to remain similar to themselves through the changes of temperature. In the early part of November, 1858, the north wind having suddenly reduced the temperature 18° Fahr. the whole bridge was seen to contract and the extremities tended towards the middle; the abutments partook partially of this motion; a slight crack between the mass of the right abutment and the viaduct, opened in the morning and closed at noon. On suppressing the mooring, the motion continued; the iron trusses were bound to the masonry solely by eight bolts of 1·97 inches secured with lead, into the stone, and resting the heels of the arches against their shoes with a screw fastening. These screws being suppressed, the abutments were immovable; but the heels of the arches separated from their shoes nearly ·39 inch. The summit of the arch then fell to its original level and resumed the form in which it had been constructed.

From this observation we conclude that the arches of the Theiss bridge exerted no thrust when unloaded, and that they could be held by simply being placed upon two supports at the springing line.

Six iron wedges in couples were driven between the heels of the arches and the shoes. In the morning the slant of the arches bore mainly upon the lower wedges, and at noon upon the upper wedges; advantage of this was taken in striking upon the upper wedges in the morning, and at noon upon the lower, so that the severest cold could not separate the heel of the arches.

In reality the arches act partly as a rigid girder, and partly as flexible arches. We observed, for example, that for a fall of 58·5°, the fourth pier remained immovable, the first advancing towards it 0·55 inches. Now, this pier is 437·8 feet from the fourth, and should approach it by 2·08 inches, if there were no change in the arches; the motion observed at the springing was 0·55 inches, proving in this case that the effect of change in temperature was divided between the piers, which received ·26, and the arches, which received the remainder.

Note B.—*Machine for making Beton.*

The beton for the Theiss bridge, was prepared in a machine widely known in Germany, but little known in France.

This simple machine is composed of a cylinder 13 feet long, and 4 feet diameter, open at its ends, and turning upon an axis inclined to the horizon. The stone and the mortar were thrown from a barrow into a hopper, which delivered them into the cylinder at its upper end. The mixture was effected by the rotation of the cylinder, whose lower end delivered the beton either into barrows or cars.

The interior of the cylinder was smooth and lined with sheet iron; the proportion of the materials was made by regulating the number of barrows of mortar and those of stone cast into the hopper. At Szegedin the cylinder was inclined to the horizon one-13th; it made from fifteen to twenty turns per minute, and the mixture was perfect. The cylinder was driven by a belt passing directly over its outer surface. Motion was given by an engine which worked at the same time a strong mortar mill.

This machine easily made from 104 to 131 cubic yards in ten hours, and so long as the loading of the materials was not included in the net cost, the expense per cubic

yard, is very small, and is but a fraction of the expense of the engines which drive the beton cylinders.

Note C.—*Pile Driving.*

At Szegedin there were three kinds of piling :—

1. The piles for the scaffolding, the service bridge, &c., were driven in the river; for the most part they were driven by steam; and the work progressed night and day. The machine gave sixty to eighty blows in one hour, the fall varying between 10 and 19½ feet.

2. The piles were driven upon the shore, for the foundation of the abutments; the pile drivers were worked by steam, with a ram 2200 pounds weight falling from 26 to 29½ feet. The heads of the piles were crushed in spite of their bands, but the parts towards the end of the driving, which jutted a little above the bottom, resisted well. The piles were of spruce. The engine worked a pump at the same time that it imparted motion to a horizontal shaft placed in front of the excavation. One or two pulleys worked the pile driver by means of a belt. A row of piles perpendicular to the horizontal shaft was driven without displacing the pulley.

3. The interior piles of the columns were driven by hand; the work went on night and day; sometimes forty hours were given to one pile, as the falls used were moderate. The ram, 880 pounds, was worked by a hand-rope of the pile driver. After 810 volleys a pile has opposed an absolute refusal during 180 volleys of 25 blows. The ram of 2200 pounds was taken; and the pile sunk 0·63 inch per blow with a fall of 9·3 feet.

These piles were cut to a diameter of 11·8 inches, so as not to tighten indefinitely the tamping of earth left in the columns; it was proved by direct experiments, that this packing consumed but a small fraction of the resistance of the pile, about one-15th, or in other words, that fourteen-15ths of the resistance of the pile was due to its fixture below the column, the only use for which it was designed.

The piles of the abutments and those of the first piers, were provided with iron shoes; but in excavating after the piling of the first pier, several detached shoes were found in the foundation, and they were abandoned in the last piers, the work being done better without them.

This experience confirms that of the Prussian engineers in the construction of the bridges of Dirschau, and of Marlenbourg upon the Vistula, in which they concluded that the shoe had no influence upon the driving of the piles. The same engineers charged with the construction of the bridge at Cologne, drove their piles unshod through the gravelly bottom. The system appeared however to be too absolute.

Deflection of Suspension Bridges. By Homersham Cox, M. A.

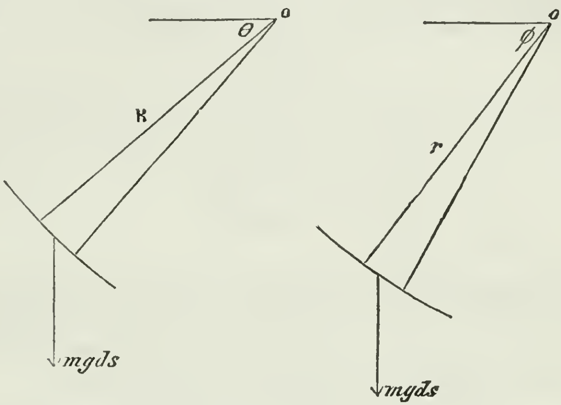
From the Civ. Eng. and Arch. Jour., July, 1861.

The following investigation of the deflection of a suspension bridge due to a deflecting weight placed at an assigned point of the bridge, is applicable not only to the case of a chain of uniform thickness, but also to the more common case in practice of a chain of varying thickness. It is believed that no investigation of this subject has been published.

The method here adopted is necessarily approximative, as the formulæ of catenaries are so complex, that it would be impossible to treat the subject with rigorous exactness. But the closeness of the following approximation to the truth is probably quite sufficient for practi-

cal purposes. It will be here supposed that the points of suspension are fixed and of equal altitude; that the platform is perfectly flexible, and subject to no horizontal tension; that the deflecting weight produces a variation of the vertical distance of each point of the chain below the points of suspension, which is small compared with that distance; and that (as in practice) that distance is small compared with the horizontal span of the bridge.

Fig. 1.



Let the small arcs in Fig. 1 represent a small element of the length of the chain before and after the deflection respectively; R r the radii of curvature of those arcs; O o their centres of curvature; $d\,s$ their length; $m\,g\,d\,s$ their weight; θ ϕ the inclinations of the radii of curvature to the horizon; T t the tangential tensions acting on the element before and after deflection respectively; C c the horizontal tensions before and after deflection respectively.

Then, since the horizontal tension at every part of a catenary is the same, $\quad \mathrm{T}\sin.\theta = \mathrm{C};\ t\sin.\phi = c \quad (1)$

The angles θ ϕ differ little from each other. Also $\sin.\theta$, $\sin.\phi$ do not greatly differ from unity, since the inclination of the chain to the horizontal is every where small. Consequently, $\dfrac{\sin.\theta}{\sin.\phi}$ differs from unity by a quantity which is small compared with unity.

Therefore, approximately, $\dfrac{\mathrm{T}}{t} = \dfrac{\mathrm{C}}{c} \quad (2)$

Resolving along the normal the forces acting on the element, we have, $\quad \mathrm{T}\,d\,\theta = m\,g\,d\,s\sin.\theta;\ t\,d\,\phi = m\,g\,d\,s\sin.\phi.$

And as before, putting the ratio of $\sin.\theta$ to $\sin.\phi$ equal to unity.

$$\frac{\mathrm{T}}{t} = \frac{d\,\phi}{d\,\theta} \qquad (3)$$

Therefore, from (2)

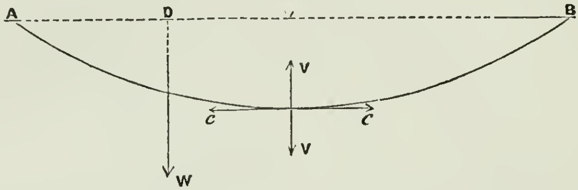
$$\frac{d\,\phi}{d\,\theta} = \frac{\mathrm{C}}{c}, \text{ and } d\,(\phi - \theta) = \frac{\mathrm{C} - c}{c}\,d\,\theta. \qquad (4)$$

Integrating equation (4), $\phi - \theta = \dfrac{\mathrm{C} - c}{c}\,\theta + \text{a constant.} \quad (5)$

It is to be observed that m is not here assumed to be constant; so that the result is not confined to the common catenary. It may be added that the relation between θ and ϕ may be found by an integrable equation, without assuming sin. $\theta =$ sin. ϕ.

In order to determine this constant we may proceed as follows: Let the curve, Fig. 2, represent the deflected catenary; W the deflecting weight acting at an assigned horizontal distance $\mathrm{AD} = a$ from the point of suspension A. Let $\mathrm{AC} = \mathrm{CB} = h$. Let the depth below AB of the middle point of the chain be k. The tension at that point is not horizontal, but has a vertical component; let this be V. The horizontal

Fig. 2.



component we have already designated c. Let the half chain suspended from A have its centre of gravity at a horizontal distance b from A, and let S be the weight of the half chain. Then taking moments about A for the equilibrium of the half chain, we have,

$$\mathrm{W} \,.\, a + \mathrm{S} \,.\, b = c \,.\, k + \mathrm{V}\, h.$$

As the displacement of every part of the chain is small, the difference between the quantity k and the value of that quantity before deflection is small compared with k. The same consideration applies to b. We may therefore define k to be the depth below AB of the lowest point of the *undeflected* chain; and b to be the horizontal distance of the centre of gravity of either half of the *undeflected* chain from its point of suspension.

Taking moments about B for the equilibrium of the half chain suspended from B we have,

$$\mathrm{S} \,.\, b = c \,.\, k - \mathrm{V}\, h.$$

From the last two equations we get,

$$\mathrm{W} \,.\, a = 2\,\mathrm{V} \,.\, h; \quad \mathrm{W} \,.\, a + 2\,\mathrm{S} \,.\, b = 2\, c \,.\, k.$$

From the last equation, putting $\mathrm{W} = 0$,

$$\mathrm{S} \,.\, b = \mathrm{C} \,.\, k. \quad \text{Therefore, } \mathrm{V} \,.\, h = (c - \mathrm{C})\, k.$$

Whence,
$$\frac{\mathrm{V} \,.\, h}{c \,.\, k} = \frac{c - \mathrm{C}}{c} \qquad (6)$$

Let a be the value of ϕ for that part of the chain which is horizontal before deflection. Since for that part of the chain $c = t \sin. a$, and $\mathrm{V} = t \cos. a$,

$$\frac{\mathrm{V}}{c} = \text{cotan. } a = \text{tan.}\left(\frac{\pi}{2} - a\right) = \frac{\pi}{2} - a \text{ nearly,}$$

since a is nearly a right angle. Hence,

$$\frac{\pi}{2} - a = \frac{\mathrm{V}}{c} = \frac{k}{h} \,.\, \frac{c - \mathrm{C}}{c} \qquad (7)$$

Returning now to equation (5), we have, when θ is a right angle and $\phi = a$,

$$a - \frac{\pi}{2} = - \frac{c - \text{C}}{c} \cdot \frac{\pi}{2} + \text{the constant.}$$

Therefore from (7) the constant $= \frac{c - \text{C}}{c}\left(\frac{\pi}{2} - \frac{k}{h}\right)$, and equation (5) becomes

$$\phi - \theta = \frac{c - \text{C}}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right) \tag{8}$$

Let the curve be referred to rectangular co-ordinates, the origin of co-ordinates being the lowest point of the undeflected chain, and the axis of x horizontal. Let x, y be the co-ordinates of the element before, $x' y'$ its co-ordinates after deflection.

$$\frac{d\,x}{d\,s} = \sin.\,\theta, \qquad \frac{d\,y}{d\,s} = \cos.\,\theta, \qquad \frac{d\,y'}{d\,s} = \cos.\,\phi,$$

$\cos.\,\phi = \cos.\,[(\phi - \theta) + \theta] = \cos.\,\theta - (\phi - \theta)\sin.\,\theta$ nearly, since $\phi - \theta$ is small.

Hence, from (8),

$$\frac{d\,y'}{d\,s} - \frac{d\,y}{d\,s} = - \frac{c - \text{C}}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right)\sin.\,\theta. \tag{9}$$

Now $d\,s$ is equal to $\text{R}\,d\,\theta$, and since the radius of curvature is every where large and varies little, we may integrate the preceding equation, assuming R to be constant.

$$d\,(y' - y) = -\,\text{R}\,d\,\theta\;\frac{c - \text{C}}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right)\sin.\,\theta.$$

$$y' - y = \text{R}\,\frac{c - \text{C}}{c}\left\{\left(\frac{\pi}{2} - \frac{k}{h}\right)\cos.\,\theta - \theta\cos.\,\theta + \sin.\,\theta\right\} + \text{a constant.}$$

Let the value of θ at the summit of the chain be β, then since at that point $y' - y$ is zero, we have from the last equation,

$$y' - y = \text{R}\,\frac{c - \text{C}}{c}\left\{\left(\frac{\pi}{2} - \frac{k}{h}\right)(\cos.\,\theta - \cos.\,\beta) - \theta\cos.\,\theta + \beta\cos.\,\beta + \sin.\,\theta - \sin.\,\beta\right\}$$

At the middle point of the chain where θ is a right angle and $\cos.\,\theta$ is zero, the deflection is

$$\text{R}\,\frac{c - \text{C}}{c}\left\{1 - \sin.\,\beta - \cos.\,\beta\left(\frac{\pi}{2} - \frac{k}{h} - \beta\right)\right\}$$

or, to express the deflection in terms of the inclination of the curve at its summit to the horizontal line, let the angle of that inclination be $\gamma = \frac{\pi}{2} - \beta$. Then the last mentioned deflection is

$$\text{R}\,\frac{c - \text{C}}{c}\left\{1 - \cos.\,\gamma - \sin.\,\gamma\left(\gamma - \frac{k}{h}\right)\right\}$$

When R is taken as constant, $R(1 - \cos.\gamma) = k$ and $R \sin.\gamma = h$. Hence we may readily show that $\sin.\gamma = \frac{2\,h\,k}{h^2 + k^2}$. Put $\sin.\gamma = \gamma$ in this expression, since γ is very small. Therefore the above expression for the deflection at the centre of the chain becomes

$$\frac{c - C}{c}\left\{ k - h\left(\frac{2\,h\,k}{h^2 + k^2} - \frac{k}{h}\right)\right\} = \frac{c - C}{c} \cdot \frac{2\,k^3}{h^2 + k^2}$$

an expression from which the deflection at the centre is easily computed. The deflection at any other point may also be found from the general expression for the deflection by substituting for $\cos.\theta$, $\sin.\theta$, and θ their equivalents in terms of the rectangular co-ordinates of the point of which the deflection is required.

The mode of computing c and C is given by the equation (6). It may be observed that in practice these tensions may be computed with sufficient accuracy by assuming the centre of gravity of each half chain to act at a horizontal distance from the summit equal to the quarter-span. This is the position which the centre of gravity would have if each half of the chain were regarded as a straight uniform bar, and the deviation of that assumption from the truth produces no considerable error. We have then for the undeflected chain the following simple formula for the horizontal tension:

$$\frac{\text{Horizontal tension}}{\text{Weight of half chain}} = \frac{\text{quarter-span}}{\text{total rise of chain}}.$$

In the common catenary this result may be obtained analytically, for if the origin be at a distance c below the lowest point of the catenary, and

$$y = \frac{2}{c}\left(\varepsilon^{\frac{x}{c}} + \varepsilon^{-\frac{x}{c}}\right)$$

Since $\frac{x}{c}$ is very small, we have by expansion,

$$y = c + \frac{x^2}{2c} \text{ nearly, or } c\,.\,(y - c) = x\,.\,\frac{x}{2}$$

which is the equation which would be obtained by equating the moments about the summit of the forces acting on the half chain, and assuming the centre of gravity to have the position last mentioned. In ordinary suspension bridges, in which the chain is somewhat more massive at the highest points than at the centre, the same equation is approximately correct, for the variation of the massiveness of the chain is not great, and it brings the centre of gravity of the half chain rather nearer to the point of suspension than is the case in the common catenary, in which the centre of gravity is at a distance from that point somewhat greater than the quarter-span. From the last equation it appears that the catenary in practical cases is very near a parabola.

MECHANICS, PHYSICS, AND CHEMISTRY.

On Combustion in Rarefied Air. By Dr. EDWARD FRANKLAND, F.R.S.

In the autumn of 1859, whilst accompanying Dr. Tyndall to the summit of Mont Blanc, I undertook at his request some experiments on the effect of atmospheric pressure upon the amount of combustible matter consumed by a common candle. I found that, taking the average of five experiments, a stearine candle diminished in weight 9·4 grammes when burnt for an hour at Chamounix; whilst its ignition for the same length of time on the summit of Mont Blanc, perfectly protected from currents of air, reduced its weight to the extent of 9·2 grammes.

This close approximation to the former number under such a widely different atmospheric pressure, goes far to prove that the rate of combustion is entirely independent of the density of the atmosphere.

It is impossible to repeat these determinations in a satisfactory manner with artificially rarefied atmospheres, owing to the heating of the apparatus which surrounds the candle, and the consequent guttering and unequal combustion of the latter; but an experiment in which a sperm candle was burnt first in air under a pressure of 28·7 inches of mercury, and then in air at 9 inches pressure, other conditions being as similar as possible in the two experiments, the consumption of sperm was found to be,—

At pressure of 28·7 inches 7·85 grms. of sperm per hour.
" 9·0 " 9·10 " " "

thus confirming, for higher degrees of rarefaction, the result previously obtained.

In burning the candles upon the summit of Mont Blanc, I was much struck by the comparatively small amount of light which they emitted. The lower and blue portion of the flame, which under ordinary circumstances scarcely rises to within a quarter of an inch of the apex of the wick, now extended to the height of $\frac{1}{8}$th of an inch above the cotton, thus greatly reducing the size of the luminous portion of the flame.

On returning to England, I repeated the experiments under circumstances which enabled me to ascertain, by photometrical measurements, the extent of this loss of illuminating effect in rarefied air. The results prove that a great reduction in the illuminating power of a candle ensues when the candle is transferred from air at the ordinary atmospheric pressure to rarefied air. It was, however, found that, owing to the circumstances mentioned above, no satisfactory quantitative experiments could be made with candles in artificially rarefied air, and recourse was therefore had to coal-gas, which, although also liable to certain disturbing influences, yet yielded results, during an extensive series of experiments, exhibiting sufficient uniformity to render them worthy of confidence. The gas was in all cases passed through a governor to secure uniformity of pressure in the delivery tubes. A single jet of gas was employed as the standard of comparison, and this

was fixed at one end of a Bunsen's photometer, whilst the flame to be submitted to various pressures, and which I will call the experimental flame, was placed at the other. The experimental flame was made to burn a uniform amount of gas, viz. 0·65 cubic foot per hour in all the experiments.

The products of combustion were completely removed, so that the experimental flame, which burnt with perfect steadiness, was always surrounded with pure air, the supply of which was, however, so regulated as to secure a maximum of illuminating effect in each observation.

In all the following series of experiments, the illuminating power given under each pressure is the average of twenty observations, which accord with each other very closely. In each series, the maximum illuminating effect, that is the light given by the experimental flame when burning under the full atmospheric pressure, is assumed to be 100. The following is a summary of the results:

First Series.		Second Series.	
Pressure of air in inches of mercury.	Illuminating power of experimental flame.	Pressure of air in inches of mercury.	Illuminating power of experimental flame.
29·9	100·0	30·2	100 0
24·9	75 0	28·2	91·4
19·9	52·9	26·2	80·6
14·6	20·2	24·2	73 0
9·6	5·4	22·2	61·4
6·6	·9	20·2	47·8
		18·2	37·4
		16·2	29·4
		14·2	19 8
		12·2	12·5
		10·2	3·6

These numbers indicate that even the natural oscillations of atmospheric pressure must produce a considerable variation in the amount of light emitted by gas flames, and it was therefore important to determine, by a special series of observations, this variation in luminosity within, or nearly within, the usual fluctuations of the barometrical column. In order to attain greater delicacy in the pressure readings in these experiments, a water-gauge was used, but its indications are translated into inches of mercury in the following tabulated results, each of which represents, as before, the average of twenty observations.

Third Series.

Pr. of air in ins. of mercury.	Illum. power of exp. flame.
30·2	100·0
29·2	95 0
28·2	89·7
27·2	84·4

It is thus evident that the combustion of an amount of gas which

would give a light equal to 100 candles when the barometer stands at 31 ins., would give a light equal to only 84·4 candles if the barometer fell to 28 ins.

An inspection of all the above results shows that the rarefaction of air, from atmospheric pressure downwards, produces a uniformly diminishing illuminating power until the pressure is reduced to about 14 ins. of mercury, below which the diminution of light proceeds at a less rapid rate. The above determinations give approximately 5·1 per cent. as the mean reduction of light for each diminution of 1 in. of mercurial pressure down to 14 ins. The following table exhibits the actually observed light, compared with that calculated from this constant.

First Series.			Second Series.		
Pressure.	Illuminating power.		Pressure.	Illuminating power.	
	Observed.	Calculated.		Observed.	Calculated.
29·9	100 0	100 0	30·2	100·0	100 0
24·9	75·0	74 5	28·2	91·4	89·8
19·9	52·9	49·0	26·2	80·6	79·6
14·6	20·2	22·0	24·2	73·0	69·4
9 6	5·4	— 3·5	22·2	61·4	59·2
6 6	·9	— 18·8	20·2	47·8	49·0
			18·2	37·4	38·8
Third Series.			16·2	29·4	28·6
			14·2	19·8	18·4
			12·2	12·5	8·2
30·2	100·0	100.0	10·2	3 6	— 2·0
29·2	95·0	94·9			
28·2	89·7	89·8			
27·2	84·4	84·7			

I am now extending this inquiry to pressures exceeding that of the atmosphere, and hope soon to lay before the Society the detailed results of the whole series, together with some observations on the causes of this variation of luminosity.—*Proceedings of the Royal Society*, March 7, 1861.

The Russian Pacific Telegraph.

From the London Engineer, No. 279.

The plan for establishing a telegraphic line connecting Europe through Siberia with the Pacific Ocean has, during four years, had time to take shape and form, so that at the commencement of the present year, the supreme sanction was given to the project for constructing a telegraphic line in the countries bordering on the Amoor and Oussouri, from Nikolaiewsk by Khabarovka to the port of Novgorod (1900 versts), the most important point of the possessions recently annexed to Russia on the Sea of Japan. The establishment of this line is undertaken by the Ministry of Marine at its cost, and under its direction; and at the same time the superior direction of the means

of communication (Board of Works) has commenced the construction of a line starting from Kasan in the direction of Siberia, which proposes opening at the end of the present year a telegraphic communication from Kasan to Omsk (1900 versts), and to continue it afterwards to Irkutsk, a distance of 2475 versts from Omsk. Thus, probably within two or three years on the one side there will be telegraphic communication between Europe and Asia to Irkutsk, and, on the other hand, our new colonies on the Amoor and Oussouri will be connected with each other, and with our principal ports on the Japanese waters. Thus of the extent of 10,000 versts which the Siberian telegraph will embrace, there only remains the central portion, that of Irkutsk by Kiakhta to Kabarovka, about 3500 versts, where as yet nothing has been settled; but it is beyond a doubt that as soon as the works actually projected shall have been successfully completed this intermediate line will be constructed, and thus within four or five years at the latest the gigantic project of a telegraphic communication from Europe to the distant lands on the shores of the Pacific Ocean will be realized. The year 1861 promises to be a memorable one, if we consider the great questions which will receive a solution. Among those questions we must place the commencement of a durable connexion and the establishment of rapid communication between Siberia and civilized Europe, and the apparatus of the electric telegraph on the virgin shores of the Amoor and Sea of Japan. It seems needless to point out the importance and usefulness of so vast an extension of improved communication by the promoters of civilization and commerce. —*St. Petersburg Gazette.*

The Separation of Silver from Galena.

From the Lond. Chemical News, No. 47.

The usual mode of separating the silver contained in lead ore, or galena, is by reducing the whole to the metallic state, and then oxidizing the lead in a particular kind of furnace; and this is done either with or without the use of the crystallizing process of Mr. H. L. Pattinson, according to circumstances. But by this means a considerable loss occurs both in lead and fuel. To prevent this loss, I have for some time successfully employed a method of separating the silver from the galena itself, which I will now describe.

Galena consists, as is well known, of the sulphuret of lead, mixed with a variable proportion of the sulphuret of silver, and both these substances fuse together, or melt at a bright red heat. Now, it so happens that, when sulphuret of silver is fused with chloride of lead, what is called a double decomposition takes place; that is to say, chloride of silver and sulphuret of lead are formed. Consequently, if we fuse together a quantity of argentiferous galena and chloride of lead, we shall remove the whole of the silver from the galena, and replace it by sulphuret of lead. This, then, is my new process: I mix together the galena and chloride of lead in the proportion of 100 lbs. of galena, 1 lb. of chloride of lead, and 10 lbs. of chloride of sodium or common salt; or, if the galena be very argentiferous, I add a larger

amount of chloride of lead. The whole is then fused together, when the chloride of silver and common salt rise to the surface, and may be skimmed off, and the desilverized galena falls and may be run out from the bottom. The mixture of chloride of silver and salt may then be decomposed by lime and charcoal, or in any other manner, so as to reduce the silver and a portion of the surplus chloride of lead, by which a metallic mass will result, suitable for the operation of the "cupell." —*Bubkil.*

On the Cause of the Loss of Strength in Iron Wire when Heated. By Mr. John Daglish.

From the London Engineer, No. 266.

During the course of some experiments on the strength of iron, the results of which were recently published in the "Transactions" of this institute, it was observed that when iron wire was subjected to a red heat its tensile strength was greatly reduced, but that, under the same circumstances, iron chain remained uninjured. An extract from *The Engineer* was also given (vol. viii, p. 14), containing some experiments lately made with *cold rolled iron*, and an expression of opinion that the great increase in the tensile strength of this description of iron was owing to "*the effect of consolidation,*" and that, when passed through a fire "*many of the pores, before consolidation, must be again opened, there arising a consequent diminution of the strength previously gained.*" Ordinary iron wire is drawn cold, and, passing through a similar process, may be considered to be similar in nature and structure to cold rolled iron, and it is also spoken of by eminent authorities as becoming "condensed and hardened" after passing a few times through the draw-plate; and that its greatly increased tensile strength is owing to this consolidation.

During late years much attention has been paid to the improvement of iron, not only by refining, de-carbonizing, and re-carbonizing, but also by adding small quantities of chemical substances, and considerable success seems to have been attained; at the same time, in some cases, the quantity of foreign matter used is so minute as to create surprise at the extraordinary results stated to have been arrived at by its use; and, again, careful analysis has proved that some excellent qualities of iron contain a considerable quantity of substances which were previously considered to be most prejudicial. Under these circumstances, it will be interesting rightly to ascertain the cause of the great variation in the tensile strength of iron wire after heating, for it is still the same material, without any change in its chemical nature or apparently in its bulk.

The generally received opinion of consolidation does not seem to the writer to be well founded. This ought to result, perhaps to a greater extent, when the iron is treated in a heated and softened state, than when drawn or rolled cold and hard, for it is natural to suppose that it would be equally readily compressed when in the former state, and it has still to undergo the contraction of cooling, which exerts a far greater consolidating force than any merely mechanical method.

If there is any permanent expansion in cold rolled more than in hot rolled iron after being heated red, the specific gravity of the body taken after and before ought to show it, and to find this the following experiments were made:

1.—Common Rolled Iron.—
A piece cut off a 3-inch rolled bar.

Before heating, .	7·600	7·549
After heating, .	7·602	7·554
Increase,	·002	·005

2.—Common Rolled Iron.—
A piece of $\frac{1}{2}$-inch bar.

Before heating,	7·582	7·579	7·579
After heating,	7·592	7·590	7·594
Increase,	·010	·011	·015

3.—Common Rolled and Hammered Iron.—
A piece cut off a large common bar, and reduced, by hammering whilst hot, to a $\frac{1}{4}$-inch rod.

Before heating, .	7·611	7·625
After heating, .	7·589	7·6
Decrease,	·002	·025

4.—Common Forged Iron.—
Cut off a piece of forged iron, and reduced, by hammering whilst hot, to a $\frac{1}{4}$-inch rod.

Before heating, .	7·737	7·756
After heating, .	7·696	7·737
Decrease,	·041	·019

5.—Common Iron Wire, $\frac{1}{8}$-inch.

Before heating, . .	7·650
After heating, .	7·669
Increase,	·019

6.—$\frac{1}{4}$-inch round hard drawn wire.

Before heating red,	7·577	7·589	7·571
After heating red,	7·555	7·580	7·559
Decrease,	·022	·009	·012

7.—Common Steel Wire, $\frac{1}{8}$-inch.

Before heating, . .	7·810
After heating, .	7·814
Increase,	·004

8.—Blistered Steel.

Before heating, .	7·829	7 827
After heating, .	7·819	7·819
Decrease,	·010	·008

9.—Cast Steel.

Before heating, .	7·804	7·833
After heating, .	7·808	7·838
Increase,	·004	·005

It appears from the above, that heating does not alter the original specific gravity to the extent of more than $\frac{1}{300}$th, and although pretty regular for the same description of iron, it sometimes causes an increase, and sometimes a decrease in the specific gravity of different qualities of iron, and no regular law is exhibited.

It will be observed that the specific gravity of hard drawn wire (6 = 7·58) is less than that of forged iron (4 = 7·74), showing that in forging the iron is more consolidated than in drawing, although its tensile strength is much less.

In the former experiments a piece of $\frac{3}{4}$-inch chain, made from a bar of carefully forged scrap iron (spec. grav. = 7·74), broke on a strain of 15 tons; whilst similar chain, made out of a bar of best rolled iron (sc. crown) (spec. grav. = 7·56), bore 24 tons.

It must be concluded, therefore, that "consolidation or condensation" is not the cause of the greatly increased strength of cold drawn wire, nor is the injurious action of red heat owing to "opening the pores," but that these effects are owing to some change in the molecular structure of the iron, not accompanied by change of bulk, or otherwise sensibly apparent.

As bearing on the point, I may also mention, as stated in *The Engineer*, that the "iron of the great Mersey gun, portions of which were

tested at Woolwich, whilst it showed a strength of 50,624 lbs. in the direction of the grain, bore only 43,339 lbs. when strained across the grain.

The Strength of Wire Ropes and Chains.—Discussion on Mr. Daglish's Paper.*

From the London Engineer, No. 266.

Mr. DAGLISH said—Since this paper was written, the following account of some experiments on cold rolled iron has appeared in *The Engineer*, which corroborate the views of the writer as to the great loss of strength in iron wire when heated to a high temperature, and of the little effect which the same treatment has on iron chains. The latter being rolled hot does not suffer any change in its molecular constitution by the application of a high heat, whilst the former having been drawn cold seems to undergo a change of structure which greatly injures its tenacity. The following are the observations alluded to:—"During the week certain of the iron-masters of South Staffordshire have been informed of the results of a series of experiments that have just been made by Mr. William Fairbairn, of Manchester, upon the tensile strength of bars of wrought iron, some of which have been subjected to a process of cold rolling, invented by Mr. Lauth, and in operation at Mr. Nasmyth's works, Patricroft. The first experiment was on a bar of wrought iron, in the condition in which it is received from the manufacturer (black). The diameter of the piece experimented upon was 1·07 in.; its area 0·85873 square inch. The laying-on of a weight of 46,426 lbs. produced an elongation on a length of 10 ins. to the extent of 1·30 in.; and the laying-on of 50,346 lbs. produced an elongation of 2·00, with a breaking weight per square inch of, in pounds, 58,628, and in tons, 26·173. The diameter at the point of fracture, after this experiment, was 0·88 in. The second experiment was on a bar similar to the preceding, but rolled cold. Diameter, 1·00 in.; area, 0·7854 square inch. With a weight of 64,255 lbs. laid on, it elongated rapidly, and the breaking weight was per square inch, in pounds, 81,812, and in tons, 36,523. The third experiment was also on a bar of iron rolled cold, with a diameter and area similar to the foregoing. The elongation of a length of 10 ins. was, in inches, 0·6, when a weight of 62,545 lbs. was laid on. With 69,295 lbs. laid on, the elongation was 0·79 in., and the breaking weight per square inch 88,230 lbs., in tons 39·388. The diameter after fracture was 0·85. The fourth experiment was on a bar of similar iron to the preceding, turned in a lathe. Diameter and area same as in the two foregoing. With a weight laid on of 30,910 lbs. the elongation was 0·15, and 2·20 with a weight of 47,710 lbs. Here the breaking weight per square inch was, in pounds, 60,746, in tons, 27,119. The diameter after fracture was 0·80. Thus it will be seen, that in an untouched or black bar the breaking weight was 50,346 lbs.; per square inch 58,628 lbs., or 26·173 tons strength, the untouched bar being unity, 1·000. That the breaking weight of a bar rolled cold was 69,295 lbs.; per square inch 88,230 lbs., or 39·388 in tons strength, the untouched

* Northern Institute of Mining Engineers.

bar being unity, 1·505. The breaking weight of a turned bar was 47,710 lbs.; the breaking weight per square inch 60,746 lbs., or 27·119 in tons strength, the untouched bar being unity, 1·006. From this it is evident that the effect of consolidation by the process of cold rolling is to increase the tensile powers of resistance from 26·17 tons per square inch to 39·38 tons, being in the ratio of 1 : 1·5, one-half increase of strength gained by the new process of cold rolling. When, however, the iron rolled cold has repassed through the fire, many of the pores before consolidated must again be opened, there arising a consequent diminution of the strength previously gained. This being the case, no use immediately occurs to us to which the bar so rolled cold can be applied with the advantage that the process must secure to the tie rod now so much used in supporting roofs in particular. Here the only portions that need be subjected to the fire are the eyes, always extra welded to maintain the same strength throughout."

From these experiments, it would seem that a 1-in. bar of hot rolled iron bore 26 tons, and the same iron when rolled cold bore 36½ tons per square inch. This agreed with his experiments on the effects of heating iron wire. He found that the strength of the wire, when heated, was reduced one-half. Wire was drawn cold, and by heating it was weakened. The same results did not apply to chains, because the iron was rolled hot, and when heated afterwards was not injured.

Mr. Berkley: Can you speak of the effect of different degrees of heat? Take the effect on ropes used in an upcast shaft, where the heat is generally considerable. What effect has such heat on wire ropes?

Mr. Daglish: The cause of the great injury done to wire ropes opposite to the exit of the furnace drift, is not owing to the direct action of the heat of the furnace itself, but to the chemical effect of its vapors principally in action at this point. The sulphur in the coals, volatilized by the furnace, combines with a portion of oxygen to form sulphurous acid, this, possessing the property of taking up another atom of oxygen when in contact with moist air, forms hydrated sulphuric acid in the upcast shaft, which, diluted with the other shaft water, passes down the rope, and as the boiling point of hydrated sulphuric acid is greatly higher than that of water, the solution increases in strength as it falls down the shaft, and becomes highly concentrated and corrosive when opposite the furnace drift, and subjected to a temperature of probably 300 degrees. Water after passing down a deep and moist upcast shaft is sensibly acid to the taste, and reddens litmus paper.

Mr. Barkus: The action of moisture upon iron in an upcast shaft is well known to have a very serious effect on wire ropes.

The President: The effect is very much increased upon that part of the rope which is stationary, immediately opposite the entrance of the furnace drift into the shaft. It is at this place where the heat is greatest, and the force of the current of air issuing out of the furnace drift striking upon the wire rope at the time the rope is stationary, which it is for a short time when the tubs are being taken out of and put into the cages, at the top and bottom of the pit.

Mr. Berkley: The effect of the heat is to evaporate the water or moisture on the rope, and to produce oxidation. Another element to be considered is the weight and effect on the chain. Where one link presses against another link the oxidation is produced more rapidly when heated by the furnace of the upcast shaft than when it is perfectly cold.

Mr. Barkus: Another circumstance operates on wire ropes by the action of the furnace in an upcast shaft. The heated air projected against the rope at the mouth of the furnace drift expands it considerably. The rope then passes rapidly into a cooler medium, and ultimately to the temperature of the atmosphere on the surface. The transition from a temperature of probably 300° to 40° or 50° produces a continual motion, or change, or alteration of the particles of the wire, and ultimately almost entirely destroys their cohesion, and the wire becomes brittle and rigid.

Mr. Daglish: The most injurious effect of the heat and moisture on ropes in upcast shafts is owing, as I have stated, to the formation of sulphuric acid. I have found in analyzing the water, that, after partial evaporation, the remaining portion was very strong acid, sufficiently so to corrode iron very rapidly, and consequently, the effect, both on the ropes and chains, is very great indeed.*

* The following conclusive experiments have since been made to test this:

		Cwt.	qr.	lb.	
1.	Single wire,	6	2	24	New wire; broken by suspending weights to them.
	Do.	6	3	10	
	Do.	6	1	24	
		6	2	19	
2.	Do.	7	0	10	Suspended for a month in the dry furnace staple at Seaton Colliery. Temperature 250 deg.
	Do.	6	3	8	
	Do.	6	3	24	
		6	3	23	

The heat, therefore, in an upcast shaft, is not sufficiently high to injure the wires of a rope.

To judge the effect of the acid water, resulting from the oxidation of the sulphur in the coals used at the furnace, three pieces, similar so the last, were hung in the wet upcast shaft.

		Cwt.	qr.	lb.	
3.	Single wire (same as 1 and 2),	5	1	0	Hung in the wet upcast shaft for twenty-eight days. Temperature 150 deg.
	Do.	4	3	10	
	Do.	4	1	10	
		4	3	10	

Showing a loss of 30 per cent.

The following additional experiments have also been made:

			Cwt.	qr.	lb.	
1.	¾-in. round common iron,		31	0	1	Broken by suspending weights.
	Do.	do.	30	0	1	
	Do.	do.	31	1	1	
			30	3	1	
2.	Do.	do.	30	1	8	Heated to a strong red in blacksmith's fire.
	Do.	do.	29	2	22	
	Do.	do.	29	2	1	
			29	3	10	
3.	Do.	do.	29	3	19	Hung in Seaton furnace dry staple for a month. Temperature 250 deg.
	Do.	do.	30	1	12	
	Do.	do.	29	1	14	
			29	3	15	
4.	Do.	do.	*a* 26	2	4	Hung in Seaton upcast shaft for a month; much damaged and eaten by acid. Temperature 150 deg.
	Do.	do.	*b* 18	0	14	
	Do.	do.	*c* 28	0	0	

Nos. 2 and 3, as compared with No. 1, prove that common rolled iron is uninjured by being subjected to a

Results of Experiments on the Strength, &c., of R. S. Newall & Co.'s Steel Wire Ropes, with a Chain-Testing Machine, in Mr. A. M'Vicar's Chain Works, Greenock, 14th March, 1859. Present—Robert Steel, Esq.; Laurence Hill, Esq.; John Galloway, Esq.; Mr. Wm. M'Millan; Mr. John Hastie, Engineer; and others.

		At a load of	Stretch in 6 ft.	Permanent stretch in 6 ft.	Broke after lifting.
		Tons.	Inch.	Inch.	Tons.
3 Pieces, each 1 15-16 inch circumference, and weighing 3·07 lbs. per fathom,	1st Piece.	10	$\frac{5}{8}$		
		12	11-16	$\frac{1}{8}$	
		15	$1\frac{3}{8}$	$\frac{5}{8}$	15
	2d "	—	—	—	15
	3d "	—	—	—	15
3 Pieces, each 2 1-16 inch circumference, and weighing 3·59 lbs. per fathom,	1st "	8	$\frac{3}{8}$		
		12	9-16	$\frac{1}{8}$	
		15	15-16	$\frac{3}{4}$	16·25
	2d "	—	—	—	16·50
	3d "	—	—	—	16·75
3 Pieces, each $2\frac{3}{8}$ inch circumference, and weighing 4·67 lbs. per fathom,	1st "	5			
		8	$\frac{1}{4}$		
		10	$\frac{1}{4}$		
		14	$\frac{1}{2}$	$\frac{1}{8}$	
		17·5	$\frac{5}{8}$	$\frac{1}{4}$	25
	2d "	—	—	—	25
	3d "	—	—	—	25
3 Pieces, each $2\frac{5}{8}$ inch circumference, and weighing 5·74 lbs. per fathom,	1st "	5			
		9	$\frac{3}{8}$		
		12	7-16	$\frac{1}{8}$	
		15	$\frac{5}{8}$	$\frac{1}{4}$	
		17·5	11-16	$\frac{1}{4}$	
		20	$\frac{3}{4}$	$\frac{1}{2}$	28·75
	2d "	—	—	—	28·50
	3d "	—	—	—	27·50
3 Pieces, each 3 inch circumference, and weighing 7·55 lbs. per fathom,	1st "	6	$\frac{1}{8}$		
		10	$\frac{1}{4}$		
		14	$\frac{3}{8}$	1-16	
		18	$\frac{1}{2}$	1-16	
		25	$\frac{3}{4}$	5-16	34
	2d "	—	—	—	34·25
	3d "	—	—	—	34·50

The following best Charcoal Iron Wire Ropes were tested at the same time, and the results were:

				Tons
1 Piece,	$1\frac{7}{8}$ inch circumference,	3 lbs. per fathom,	. .	6
1 "	$2\frac{7}{8}$ " "	7 " "	.	16
1 "	$3\frac{3}{8}$ " "	9 " "	. .	20
1 "	$3\frac{3}{8}$ " "	9 " "	.	21·25
1 "	$3\frac{1}{2}$ " "	10 " "	. .	22·50

high temperature, and are corroborative of the previous experiments. No. 4 also shows the injurious effect of moisture in an upcast shaft: the centre piece (*b*) was most exposed to the action of the acid water.

In order to ascertain the amount of free acid in the water in an upcast furnace shaft, a portion, taken out of the Seaton shaft near to the exit of the furnace drift, and about 220 fathoms from the surface, has been tested by Mr. Lindsay Wood and myself. We find it to contain about one grain of sulphuric acid (SO_3, HO) in 700, or about ·14 per cent. About eight tons of small coals are consumed by the furnace in twenty-four hours.

Mr. Boyd: Have you any analytical experiments on wire made from cold drawn wire after it has been heated?

Mr. Daglish: There is no chemical change by merely heating iron. There is a change in the molecular arrangement.

The President: Have you any further observation to make as to steel wire ropes?

Mr. Daglish: I have given the result of two experiments made myself with steel wire ropes, and I have been furnished with a copy of some experiments made recently at Greenock, which have not been published, but seem to be well authenticated. In reference to the splicing of wire ropes and to the effect of broken wires, several experiments were made, I believe at Wingate Grange, some years since; one of these agrees very closely with mine; each wire in a strand of six wires was cut 12 inches apart. The strand then bore 12 cwts.

Wooden Substitutes for Whalebone.

From the London Chemical News, No. 47.

Many unsuccessful attempts have been made to obtain a perfect substitute for whalebone for the manufacture of the ribs of umbrellas and parasols. A Mr. Ball has found that by selecting the butt end of white oak timber, of what is termed the "second growth," and of straight rib and free from knots or curls, and, in no case, using more than six feet from the ground or stump, and subjecting it to a certain process of curing, it is made to serve not merely as a substitute for whalebone, but is converted into an altogether superior article, as it is not only tougher and possesses greater tenacity than whalebone, but the ribs made from it always resume their straight condition after exposure to the weather.

Melting Zinc by Gas.

From the London Chemical News, No. 47.

The melting of zinc, which is generally performed in plumbago crucibles over a coke fire, requires an elevated temperature that is difficult to regulate. If the temperature becomes too high, it causes a loss of zinc by evaporation and burning, and it also seriously injures the quality of that which remains; the oxide of zinc resulting from combustion mixing mechanically among the metallic mass and producing what is termed burnt zinc. This accident occurring daily in zinc foundries, aroused the attention of Mr. Miroy to the advantages of employing gas in this operation. His apparatus consists of a cast iron crucible placed upon an upright cylinder in a conical furnace, where the gas is burned. This furnace is formed of two concentric envelopes of iron plates, separated by a layer of sand; or it may be of fire-brick. The gas is brought in obliqnely from the two sides by two pipes, each concentric to a larger pipe, leading compressed air; the gas-pipe being ·6 of an inch in diameter, and the air-pipes being 2·8 inches. Mr. Miroy estimates that the volume of air employed should be triple that

of the gas, and this proportion is regulated by stop-cocks in the pipes. The air is forced into the pipes by a blower driven by a power. The melting by gas is more rapid and less costly than the fusion by coke, especially when a crucible has to be mounted for a single melting. There is also a great saving in the cost of crucibles.

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 10.—(*Continued.*)

EFFECT OF IMPACT ON CAST AND WROUGHT IRON.

(Continued from page 127.)

Horizontal and Vertical.—The power of a bar, beam, &c., to resist impact varies with the mass of the bar, &c., the striking body being the same, and by increasing the inertia of the bar, &c., without adding to its strength, the power to resist impact is, within certain limits, also increased.

Hence, weight is an important element in structures exposed to concussion.

If blows of equal magnitude are given upon the middle of a bar, beam, &c., either by elastic or inelastic bodies of the same weight, the same effect will be produced.

The *resilience*, or power of springing back of a bar, beam, &c., resisting a transverse impulse, follows a law very different from that determining its transverse strength, as it is simply proportional to the bulk or weight of the bar, &c., without any reference to the form of the section of it, or whether it is solid or hollow.

Thus, a bar, &c., 10 ft. in length will support but half the load without breaking that one of the same breadth and depth which is 5 ft. in length; but it will bear the impulse of a double weight striking against it with a given velocity, and will require that a given body should have a double momentum to break it.

The ultimate deflections of bars of different sections, struck with like weights and velocities of them, will differ in the proportion of the product of the squares of the section in the direction of the impact and the dimension of the section perpendicular thereto.

The ultimate breaking deflection of bars, &c., of like dimensions of section compared with others having twice the length between their supports, is somewhat greater than one-fourth, and the vertical* distance fallen through by the body of impact, to produce fracture is somewhat more than one-half.

Hence, the depth fallen through to break the bar of half the length, is nearly half of that required to break the bar of whole length.

When bars, &c., are struck in the middle between the centre and one support, the chords of impact necessary to produce fracture are

* The versed sine of the arc described by the oscillation, or swinging of a body of impact.

nearly equal in both cases and the ratio of the deflections from equal impacts are nearly constant under different increasing degrees of impact; the deflections from the centre between the supports from equal impacts, being to those at one-fourth the distance as 10 to 7 nearly.

With bars, &c., of like dimensions and distance between their supports, struck with balls of different weights, the ultimate deflection is very nearly equal, but the vertical descent of the ball is very nearly in the inverse ratio of the square of the weight.

In cast iron bars, &c., the deflections are greater than, in proportion to the velocity of impact; whilst in wrought iron they are very nearly constant with impacts of different velocities.

Bars, &c., when uniformly loaded, resisted greater impacts from like weights than when unloaded; in same proportion of loading, the resistances were as 2 to 1.

From a number of experiments on the impact of cast iron bars, it appeared that but a very few of them withstood 4000 blows, each deflecting them through half of their ultimate deflection; but all the bars when sound withstood this number of blows, each deflecting them through one-half of their ultimate deflection.

Bars, beams, &c., subjected to a regular depression equal to the deflection due to a load of one-third of their statical breaking weight, will bear 10,000 successive depressions, and when broken by statical weights will bear as great a resistance as like bars subjected to a like deflection by statical weight.

TABLE *of the Results of Experiments on the Continued Impact of Cast and Wrought Iron Bars.*—(Rep. of Com. on Railway Structures.)

IMPACT AND MATERIAL.	Distance between the supports.	Weight of striking ball.	Radius of arc of oscillation of ball.	Dimensions of Bar.		Weight of bar between supports.	Ultimate deflection.	Set.	Chord of arc of impact.	Height fallen through by ball at each blow.	Velocity of impact of ball per second.	Ultimate work done by the ball.	Breaking weight of like bar by vertical transverse pressure.	Ultimate deflection by breaking vertical pressure.
				In deflection of impact	Perpendicular to impact.									
Horizontal.	Feet.	lbs.	Feet.	Inch.	Inch.	lbs.	Inch.	Inch.	Inch.	Feet.	Feet.	lbs.	lbs.	Inch.
Cast	13·5	603	17·5	3·046	3·036	378	4·875	·783	79	1·238	8 925	747	3000	4·55
Iron.	13·5	603	17·5	1·53	6·122	381	9·	1·320	78	1·207	8·812	728	1500	
	13·5	603	17·5	6·095	1·538	834	2·4	2·635	80	1·270	9·038	766	6000	
	6·75	603	17·5	3·	3·	193	1·23	·164	56·75	·639	6·411	385	6000	1·272
	9·	151·3	17·5	2·012	1·983	108	2·75	·296	80·5	1·286	9·094	194	750	
	9·	75·5	17·5	1·974	2·001	106	2·83	·320	124·	3·051	14 008	230	750	
Wrou't	4·5	75·5	17·5	2·	2·	54	·892	·131	98·5	1·925	11·128	145	1500	
Iron.	13·5	151·3	17·5	1·515	5·523	372	3·	·040	119·8	2·845	13·528	430	—	
	13 5	603	17·5	1·515	5·523	372	4·	—	61·18	·743	6·913	448	—	
Vertical.	13·5	303	—	1·522	5·018	338	5·182	3·82	—	3·	13·892	909	—	
C'st iron	13·5	303	—	3·	3·	382	3·745†	—	—	2·625	12·995	795	3000	4 55
	13·5	303	—	3·	3·	779*	3·786†	—	—	3·5	15·005	1060	3000	4·55
	13·5	303	—	3·	3·	1343*	3·338†	—	—	4·5	17·015	1363	3000	4·55

* Loaded uniformly with additional weight.
† Broke at impacts due to a height of 33, 45, and 60 feet, respectively.

To ascertain the Weight of the Body of Impact that can be sustained by a Rectangular Bar, &c., of Cast Iron.

When the Velocity of the Body, the area and length of the Bar, &c., are given.

RULE.—Divide the product of 45 times the length between the sup-

ports of the bar in feet by the area of the section in inches, by the square of the velocity of the body of impact in feet per second, and the quotient is the weight required.

Or, $$\frac{45\ l\ b\ d}{v^2} = \text{w}.$$

EXAMPLE.—A beam of cast iron 13·5 ft. in length between its supports and 3 ins., square is struck by a ball with a velocity of 10 ft. per second: what is the weight of the ball?

$$\frac{45 \times 13{\cdot}5 \times 3 \times 3}{10^2} = \frac{5467{\cdot}5}{100} = 54{\cdot}675 \text{ lbs.; the weight of the ball.}$$

When the Height of the Fall is given.

Proceed as when the velocity is given, substituting for it 64·3 times the height of the fall.

To ascertain the area of a Cast Iron Beam that can sustain a given Impact.

When the Velocity and Weight of the Body of Impact and the Length of the Beam are given.

$$\frac{v^2\ \text{w}}{45\ l} = b\ d.$$

To ascertain the Velocity of the Body of Impact that can be sustained by a Cast Iron Beam.

When the Weight of the Body, the Length and Area of the Beam are given.

$$\frac{45\ l\ b\ d}{\text{w}} = v^2.$$

To ascertain the Weight of the Body of Impact on Cylinders, Grooved, and Open Beams of Cast Iron.

Grooved beam. $$\frac{45\ l\ b\ d\ (1 - q\ p^3)}{v^2} = \text{w}.$$

Open beam. $$\frac{45\ l\ b\ d\ (1 - p^3)}{v^2} = \text{w}.$$

Rectangular ellipse. $$\frac{58\ l\ b\ d}{v^2} = \text{w}.$$

Grooved ellipse. $$\frac{58\ l\ b\ d\ (1 - q\ p^3)}{v^2} = \text{w}.$$

Open ellipse. $$\frac{58\ l\ b\ d\ (1 - p^3)}{v^2} = \text{w}.$$

Results of Experiments to determine the Resistance of Cold and Hot Blast Irons to Vertical Impact.

The bars were of uniform dimensions, and were struck with a hammer when lying horizontally on supports.

Cold blast, . .	15 blows.
Hot " .	2 "

The power to resist impact, as determined by Mr. Fairbairn, upon

a number of specimens of English, Welsh, and Scotch irons, 1 inch square and 4·5 feet between the supports, the highest in the order of their powers of resistance to transverse stress, was a mean of 817.

On a new Method of Producing on Glass, Photographs or other Pictures, in Enamel Colors. By F. JOUBERT.

From the Journal of the Society of Arts, No. 444.

Of all the inventions to which the genius of man has given birth, and which have been progressively developed and brought by his industry to a high degree of perfection and usefulness, the art of glass-making is certainly one of the most interesting and extraordinary; at the same time as it is doubtless one which has tended to increase our comforts and our enjoyments in a degree almost unequalled by any other discovery of modern civilization.

If we look back to the dark ages, and find that in those days even the rulers of the earth had no means of keeping rain and bad weather from their habitations, except by also shutting out the light, we shall be ready to acknowledge the astonishing results, as compared with the present state of things around us, which the persevering efforts of man have, under the guidance of an ever-merciful Providence, been able to accomplish.

Before entering into the description of the process which is more immediately the subject of our meeting this evening, I would in a concise manner, and, as far as the necessarily limited time I have to occupy this place will allow me, recapitulate the history and progress of the invention of glass itself, and of glass painting which has led to the process before us.

We have no distinct evidence to show what nation first used glass, and we must therefore be satisfied with the various traditions transmitted to us from age to age, on the subject. One fact, however, seems established beyond the possibility of a doubt, viz: that the greatest antiquity can be assigned to this invention, since the Egyptians and the Phœnicians had both vessels and ornaments made of glass, crude in form, but of a substance so perfect, by whatever means obtained, that it has stood the trial of several thousand years, and may be pronounced to have suffered no deterioration. Might we not, in consequence, assign to glass a place in the list of useful inventions far higher than that which it occupies? for in this we have a discovery, the first inventors of which seem to have attained, at once, the very condition—durability—which humankind is incessantly bent upon obtaining for any produce of its hands.

But still more remote is the mention of glass in the Holy Scripture; for, if the interpretation of the text be a correct one, in the 18th chapter of Job, as also in several other parts of the Bible, is found an allusion to a substance which we imagine must have been glass. Next to this, Alexander Aphrodisius amongst the ancient Greeks, Lucretius, Flavius Vopiscus, and other Latin authors, have left us a correct description of glass. Aristophanes also alludes to glass in one of his

plays, and Aristotle brings out two problems on the subject: the first, why is it we see through glass? the second, why can we not bend glass?

Admitting that these two propositions emanate from the celebrated philosopher, they appear to give conclusive evidence that glass was familiar to the Greeks.

But we may, perhaps, even trace the origin of this invention far earlier, and to the remotest period of the existence of man, by associating it with the art of making bricks, which was, it is believed, practised by the earliest inhabitants of the earth; and it is not difficult to imagine how such an art would originate.

Man was led, for his subsistence, to seek a mode of preparing animal food for his use by roasting it over the fire, and having, in the course of time, built, rudely, a sort of oven made of earth, and the earth having become hardened through the action of the fire, our forefathers would soon discover all the advantages which might be derived from such a process for making bricks or pots, and utensils for common use. Specimens of the potter's art in ancient times we have in plenty, and in a variety of forms or shapes, which for elegance have not been surpassed. We need only allude to the Etruscan vases in the collection of the British Museum.

In firing bricks it will not unfrequently happen that some kind of vitrification takes place in the bricks placed in the hottest part of the fire, and one might naturally suppose that one process would lead to the other; but such does not appear to have been the case, at any rate, for many centuries. Later, horn and skins were in use down to the third or fourth century of the Christian era, and oiled paper or mica was also used in lieu of window glass, nearly up to the time of the reign of Elizabeth. If we are to give credence to the narrative of Pliny, to accident alone, as in many other instances, are we indebted for the discovery of glass. Some traders, being weather-bound, landed on the banks of a river in Syria, and began to prepare a place in the sand for cooking their meals, after having gathered for fuel a great quantity of an herb, known there by the name of *kali*, which plant must have contained a large proportion of carbonate of soda, and this being mixed with the sand, yielded, through the agency of the fire, a sort of vitreous substance. Such is one of the accredited versions of the origin of glass.

Glass has at all times, until recently, been thought a substance of great importance, and even amongst the primitive inhabitants of South America, and of the Indian continent, who were, when first visited by the early European navigators, found to possess gold and silver ornaments in abundance, it is well known that the first discoverers of those countries who happened to land in search of food or water, had no difficulty in obtaining from the natives gold in exchange for some valueless pieces of glass, or a few glass beads which they would immediately use as an ornament round their necks or their wrists. As late as the middle of the last century, glass beads of various descriptions and of all sorts of colors, were extensively manufactured in France,

principally for exportation to the colonies of South America and the islands of the Pacific Ocean.

It may be said that although glass is an article of first necessity to us, it is at the same time one with the nature of which very few persons are well acquainted, and the learned have even been often at variance as to the exact classification glass ought to belong to. It is not a mineral, since it has never been found in a primitive state in any country, neither can it be placed in the vegetable kingdom.

Glass has become with us an article so singularly cheap and common, that we are apt to lose sight of its immensely diversified qualities; but if only considered from a philosophical point of view, we shall find that few of the substances which we have in daily use, either in a simple or compound state, can be compared to glass in point of importance and of usefulness. Firstly, unlike any mineral, it is inodorous and clean to the fingers, and does not lose any of its weight by usage or wear; it is always transparent, whether in a cold or a red-hot state; it can take any shape whatever while in a state of fusion, and it retains it absolutely after it has cooled. It is capable of receiving the highest polish, and of taking any colored tint, either on its surface or in its body; and it also has this peculiar and invaluable advantage that it does not retain the taste of any liquid or acid it may have contained; it is the most flexible of substances while in fusion, and becomes harder than any pure metal when once it has become cold; lastly, it is not liable to rust, nor to be consumed by fire.

The applications of glass are now so numerous that it is difficult to imagine any one branch of industry or of manufactory which could be carried on for a single day without the use of glass in one shape or another. To some of the most important amongst the sciences, such as chemistry, physics, astronomy, the use of glass is a matter of absolute necessity; and in proportion to the gradual and increasing requirements of these last-named sciences, especially astronomy, it will be found that the glass manufacturer has been obliged to perfect his mode of manipulation, and, by the aid of chemistry, has of late years obtained such magnificent results that the field for astronomical observation has thereby been considerably enlarged.

It appears that, although vessels made of glass had been in use for a considerable time previously, it was only about the third century of our era that glass began to be used for glazing windows. These consisted of an infinite number of small panes of various shapes, which were arranged so as to form certain designs for the ornamenting of windows in places of worship; glass having, on account of its rarity then, been almost, if not entirely, confined to that use.

St. Jerome, who wrote in the fourth century, speaks of glass in church windows; and Grégoire de Tours relates, two hundred years later, in the year 525, that a soldier of the army of the King of the Visigoths, which had invaded Auvergne, entered a church through a window, of which he broke the glass. Fortunatus, Bishop of Poictiers, towards the end of the seventh century, describes with admiration the painted windows of the Cathedral of Paris. St. Philibert, also in the

seventh century, had the windows of the celebrated Abbey of Jumièges on the banks of the Seine, near Rouen, decorated with glass.

At the beginning of the eighth century glass was unknown in England, and it was Wilfrid, Bishop of York, who died in 709, who first introduced glass into England, by sending for some glass-makers from France, according to a record kept to this day. A few years later, St. Bennet, Abbot of Wearmouth, wishing to decorate the windows of his monastery, sent for some glass-makers, also from France, for it appears, from some authentic records, that the art of decorating windows with glass was practised in several parts of France, especially in Normandy, long before it was adopted in other countries.

It would seem that the art of staining glass was very early discovered, although no date can be correctly assigned to the period when stained glass for church windows was first used. The practice generally adopted was to make a sort of mosaic design, by placing an infinite number of small pieces of colored glass together. This was in use for several centuries before the art of painting on glass, properly speaking, was discovered, which seems to have soon extensively spread and to have been cultivated by many excellent artists, to judge by the numerous specimens still in existence on the continent. But for the 16th century, so rich already in artistic talent, was reserved the glory of carrying glass painting to a degree of excellence which has never been equalled since, and the names of Jean Cousin and Bernard de Palissy will be honored forever, amongst the large phalanx of glass painters in all countries. The most remarkable painted windows, perhaps, in this country, are the windows of the various Colleges at Oxford, which were executed during the 17th century by Bernard Van Linge and his pupils. William Price also repaired some of the glass paintings in Queen's College, Oxford, and in Christ Church painted a remarkable composition from the designs of Sir James Thornhill. Besides these may be mentioned the windows of Lichfield Cathedral, and several other very ancient windows in Christ Church, and especially in the residence of the Dean of Westminster, near the Abbey.

Having been, for many years, professionally acquainted with printing in connexion with the fine arts, and having observed the immense development the new art of photography has taken, and the large field it has opened for representing all sorts of subjects, of animated, as well as still life, it occurred to me that if a means could be found to print the photographic image on glass, as easily as it is done on paper, and through the agency of some chemical composition which would admit of employing ceramic or vitrifiable colors, and burning them in, a great result would be attained, and a new and considerable branch of industrial art might thereby be opened. Considering the numerous and various attempts which have, from time to time, been made to introduce a substitute for glass painting in the decoration of houses, I believe it can be said that a want was generally felt for supplying the growing taste for pictorial decoration; for glass painting is an expensive process, and requires also a considerable time to obtain a perfect result. There is a process known as lithophany, or transpa-

rent china, or biscuit slabs, which are now made, in Germany principally, and some very good specimens can be seen, but although any kind of subjects, on a small scale, can thus be represented, and with a very good effect, the slabs are heavy and thick, and can never come into use as a substitute for glass painting. Some few years ago, a new mode, which was then termed "potichomany," was introduced, which had for a short time very great success—I allude to the mode of pasting colored prints inside a large glass bowl, or jar, and applying a thin layer of plaster of Paris, in a liquid state, so as to fix the paper firmly, and create an opaque back-ground, by giving substance to the whole, when seen from a distance. Some very good specimens of this were obtained, and it afforded for a time an agreeable occupation to many a young lady. Another mode has also been tried, and some very pretty results produced, by applying prints obtained by lithochromy, or lithographic printing in colors, on a pane of glass, and varnishing them at the back with copal or some such varnish; these will for some time resist the effects of the weather when placed in a window, and this is perhaps the nearest approach to glass painting in point of effect yet achieved, but practically it does not answer, for the varnish will not stand exposure to the weather from outside, and the constant cleaning glass requires, renders it liable to be injured, so that the design soon perishes.

In the mode which is now for the first time introduced, no such danger or liability need be feared, since the color has been firmly fixed in the substance of the glass by fire, and, being composed of the same elementary materials, has become part of the glass itself, and can only be destroyed by the glass being annihilated by breakage.

In order that the process may be very distinctly understood, I shall now describe it by reading that part of my specification which relates to the placing the image on the glass, fixing it, and passing it through the fire.

This invention has for its object improvements in reproducing photographic and other pictures, engravings, prints, devices, and designs, on the surfaces of glass, ceramic, and other substances requiring to be fired to fix the same thereon.

For this purpose, I proceed in the following way:—A piece of glass, which may be crown or flatted glass, being selected as free from defect as possible, is firstly well cleaned, and held horizontally while a certain liquid is poured on it. This liquid is composed of a saturated solution of bichromate of ammonia in the proportion of five parts, honey and albumen three parts of each, well mixed together, and thinned with from twenty to thirty parts of distilled water, the whole carefully filtered before using it. The preparation of the solution, and the mixing up with other ingredients, should be conducted in a room from which light is partially excluded, or under yellow light, the same as in photographic operating rooms, so that the sensitiveness of the solution may not be diminished or destroyed.

In order to obtain a perfect transfer of the image to be reproduced, the piece of glass coated with the solution, which has been properly

dried by means of a gas-stove (this will only occupy a few minutes) is placed face downwards on the subject to be copied in an ordinary pressure frame, such as is used for printing photographs.

The subject must be a positive picture on glass, or else on paper rendered transparent by waxing or other mode, and an exposure to the light will, in a few seconds, according to the state of the weather, show, on removing the coated glass from the pressure frame, a faintly indicated picture in a negative condition. To bring it out, an enamel color, in a very finely divided powder, is gently rubbed over with a soft brush until the whole composition or subject appears in a perfect positive form. It is then fixed by alcohol in which a small quantity of acid, either nitric or acetic, has been mixed, being poured over the whole surface and drained off at one corner.

When the alcohol has completely evaporated, which will generally be the case in a very short time, the glass is quietly immersed horizontally, in a large pan of clean water, and left until the chromic solution has dissolved off, and nothing remains besides the enamel color on the glass; it is then allowed to dry by itself near a heated stove, and when dry is ready to be placed in the kiln for firing.

It may be stated that enamel of any color can be used, and that by careful registering, a variety of colors can be printed one after the other, so as to obtain a perfect imitation of a picture; also that borders of any description can be subsequently added, such as those shown in the specimens on the table, without any liability to remove or even diminish the intensity of the color in the first firing.

It will be easy to perceive that this mode of obtaining an image on glass, in an absolutely permanent substance, and of any description, color, or size, may prove of considerable advantage and utility for the decoration of private houses, and also for public buildings. Now that, by means of the photographic art, the most correct views of any object or of any building or scene—even portraits—can be faithfully and easily obtained; when we see every day the results of the labors of photographers in all parts of the world, in the shape of beautiful prints; when we can be made acquainted, without leaving home, with the actual costume, habitations, scenery, manners almost, of all countries, for instance, China and Japan, which have but recently opened their doors to European civilization; when through the same means, we are able to see, for the first time, and the learned are able to translate from, the graphic reproduction with which photography furnishes us of those early inscriptions engraved on the rocks in Asia, and by the Egyptians on their splendid monuments, I need only point out the usefulness of the mode of fixing those images, in an indelible manner, for ornamental as well as for scientific purposes.

In large cities, like London, where houses are built so close to one another, in how many places may not the process become available, by enabling any one to introduce, for a very moderate expense, pleasing or instructive images where common plain ground glass is now used, to shut out the sight of a disagreeable object, a dead wall, or an

unpleasant neighbor, without diminishing the amount of light more than is convenient.

In the library, fitting subjects might be introduced on the windows by a judicious selection of the portraits of favorite authors, or of famous scenery at home or abroad. In the dining room, also, appropriate pictures could be selected, such as flowers, fruit, or game subjects, so disposed as to harmonize with the decoration of the room. Even for domestic purposes, for lamps or screens, or any object in glass, the process will be found useful, especially on account of its rapidity, which will enable the manufacturer to execute and to deliver an order at a very few days notice.

(To be Continued.)

Production of Valuable Manure from the Air. By MM. MARGUERITTE and DE SOURDEVAL.

From the London Chemical News, No. 46.

The value of guano and most other concentrated manures consists to a considerable extent of the ammonia which they contain. As three-quarters of the atmospheric air consists of nitrogen, and as hydrogen forms one-ninth of all pure water, if some cheap means could be found for inducing the hydrogen of water to enter into combination with the nitrogen of the air in the form of ammonia, this valuable manure could be produced in unlimited quantities, and the agricultural products of the world enormously increased. The efforts to do this have been, at last, crowned with success, as will be seen by the following abstract of some recent continental researches.

Since the remarkable labors of Messrs. Liebig, Schaltenmann, and Kuhlmann, on the fertilizing action of ammoniacal salts, the production of ammonia at a low price has become a problem of the highest interest to agriculture. But to arrive at this result it is necessary to obtain the nitrogen elsewhere than in nitrogeneous matters; which may, for the most part, be employed directly as manures, and of which the limited quantities and elevated price permits in any event only restricted and costly manufacture.

Atmospheric air is an inexhaustible and gratuitous source of nitrogen. However, this element presents so great an indifference in its chemical reactions, that, notwithstanding the numerous attempts which have been made, chemists have not heretofore succeeded in combining it with hydrogen so as to produce ammonia, artificially. This result, so long desired, has been reserved for MM. Margueritte and De Sourdeval, who have obtained it by employing an agent of which the remarkable properties and neat and precise reactions have permitted them to succeed where all others have failed. This agent is baryta, of which notice has recently been taken on account of the recent applications that M. Kuhlmann has made of it in painting, but of which no person suspected the part that it was to be called to play in the development of the agricultural riches of our country. The manufac-

ture of ammonia is based on a fact entirely new, the cyanuration of barium. It had been believed until the present time that potash and soda alone had the property of determining the formation of cyanogen; that the earthy alkaline bases—baryta, for example, could not, in any case, form cyanides.

Messrs. Margueritte and De Sourdeval have ascertained that this opinion is entirely erroneous, and that baryta, much better than potash or soda, fixes the nitrogen of the air or of animal matters in considerable proportions. It is already understood that, for the preparation of Prussian blue, the cyanide of barium presents great advantages over that of potassium, for the equivalent of baryta costs only about the one-seventh of that of potash. Thus do we find practically and really obtained the result first announced by Desfosses and vainly pursued in France and England, the manufacture of cyanides from the nitrogen of the atmospheric air. This solution, so important, depends on the essential difference which exists between the properties of baryta and those of potash; the first is infusible, fixed, porous, and becomes deeply cyanuretted without loss; the second is fusible, volatile, and becomes cyanuretted only at the surface, and suffers by volatilization a loss which amounts to 50 per cent. After the cyanide of barium was obtained, the grand problem for Messrs. Margueritte and De Sourdeval to resolve was the transformation of the cyanide into ammonia by means at the same time simple, rapid, and inexpensive. The following is the operation:

In an earthen retort is calcined, at an elevated and sustained temperature, a mixture of carbonate of baryta, iron filings in the proportion of about 30 per cent., the refuse of coal tar, and saw-dust. This produces a reduction to the state of anhydrous baryta, of the greater part of the carbonate employed. Afterwards is slowly passed a current of air across the porous mass, the oxygen of which is converted into carbonic oxide by its passage over a column of incandescent charcoal, while its nitrogen, in presence of the charcoal and of the barium, transforms itself into cyanogen and produces considerable quantities of cyanide. In effect, the matter sheltered from the air and cooled, and washed with boiling water, gives with the salts of iron an abundant precipitate of Prussian blue. The mixture thus calcined and cyanuretted is received into a cylinder of either cast or wrought iron, which serves both as an extinguisher and as an apparatus for the transformation of the cyanuret. Through this cylinder, at a temperature less than 300° (Centigrade) is passed a current of steam, which disengages, under the form of ammonia, all the nitrogen contained in the cyanide of barium. It is impossible to foresee all the results of this great discovery. Among other things, it suggests the production of nitric acid from the air by oxidizing ammonia.

The whole ordinary pressure upon all the internal surfaces of a locomotive boiler of the largest class (including the tubes) is about 15,000 tons.

*On the Preparation of Artificial Coloring Matters with the Products Extracted from Coal Tar.** By M. E. Kopp.

From the Lond. Chemical News, No. 38.

The dry distillation of organic matters, whether vegetable or animal, from the great variety of products to which it gives rise, constitutes one of the most interesting operations of chemistry. The reactions to which these products owe their origin are very complex, and some of them have been but little studied, as indeed is the case with many of the substances formed. If the body submitted to dry distillation could be maintained during the operation under uniform conditions of desiccation, temperature, and pressure, the reactions and the products would be much more simple. If, for example, wood be heated very slowly in close vessels, first to 100° C., then to 200°, 300°, and so on, there is at first disengaged almost pure water, then impure strong acetic acid, and afterwards a mixture of acetone and acetate of methylene; the maximum of charcoal is left as residue, and the least amount of tar and gas is produced, the latter consisting only of carbonic acid and carburetted hydrogen.

In practice, however, when wood is distilled in cylinders of iron heated from the outside, the heat only penetrates to the interior gradually. The outside layers are therefore the first decomposed; they at first lose water, then furnish pyroligneous acid and wood-spirit, at the same time giving off carbonic acid and a little carburetted hydrogen. The inner layers in turn are similarly decomposed; but the products as they are given off are brought into contact with the outer layer, already in a more advanced state of decomposition and at a much higher temperature, and hence new reactions take place and new products are formed. Thus, the vapor of water in contact with red hot charcoal is decomposed, and forms carbonic acid and hydrogen; a part of the carbonic acid is again decomposed by the red hot carbon to form some carbonic oxide; a part of the nascent hydrogen combines with carbon to form various hydrocarbons; one part of the acetic acid is decomposed by the high temperature to form acetone and carbonic acid; another part reacts on the wood-spirit and forms methylic acetate; a fraction of the wood-spirit and acetone are also decomposed, producing tarry matters, pyroxanthrine, oxyphenic acid, dumasine, &c. To these must be added the influence of certain nitrogenized bodies, and we can understand how all these compounds, successively formed under the most favorable circumstances for acting on one another, since they are in the nascent state, and exposed to a high temperature, may give rise to the formation of a great variety of very different compounds which will be set free either in that state of a permanent gas, or a condensable vapor, and leave fixed carbon as a residue. The same takes place whether wood, coal, bituminous schists, boghead coal, asphalte, peat, resin, oils or animal matters be distilled; but it is evident that the original composition of the material submitted to dry distillation must powerfully influence the nature and composition of the products.

* Abridged from the *Moniteur Scientifique*, t. ii., liv. 86.

In those which, like wood, are rich in oxygen and poor in nitrogen, the pyrogenous products contain much acetic acid and but little ammonia, and consequently have an acid reaction; on the contrary the matters containing much nitrogen, and but little oxygen, like coal and animal matters, give rise to the formation of much ammonia, and the products have an alkaline reaction.

We intend in this article to confine our attention to the products obtained by the distillation and rectification of the coal tar from gas works. Considerable differences are noticed in the composition of the tar procured from different qualities of coal and schists, according to the rapidity with which the distillation has been conducted. Some tars, for instance, contain but little benzole and much naphthaline; boghead tar is rich in paraffine; others contain a preponderating quantity of phenol and benzole.

Table of the Products obtained by the Distillation and Rectification of Coal Tar.

	Liquid Products.			
Solid Products	Acids.	Neutral.	Bases.	Gaseous Products.
Carbon.	Rosolic.	Water.	Ammonia.	Hydrogen.
Naphthaline.	Brunolic.	Essence of tar.	Methylamine.	Carburetted hydrogen.
Paranaphthaline, or Anthraceine.	Phenic, or Phenol.	Light oil of tar.	Ethylamine.	Bicarburetted hydrogen.
Paraffine.	Acetic.	Heavy oil of tar.	Aniline.	Various hydrocarbides.
Chrysene.	Butyric.	Benzole.	Quinoline.	Carbonic oxide.
Pyrene.		Toluole.	Picoline.	Sulphide of carbon.
		Cumole.	Toluidine.	Carbonic acid.
		Cymole.	Lutidine.	Hydrosulphuric acid.
		Propyle.	Cumidine.	Hydrocyanic acid.
		Butyle.	Pyrrhol.	
		Amyle.	Pætinine.	
		Caproyle.		
		Hexylene.		
		Heptylene.		

Whatever may be the composition of the different kinds of tar, they are all submitted to distillation in order to isolate the principles capable of industrial application. But first of all it is necessary to separate the tar, as far as possible, from the ammoniacal liquor which is found with it. For this purpose it is heated some hours to 80° or 100° C. by which it is rendered more liquid, and then the water separates more easily. It is then allowed to cool very slowly, and the water is drawn off by a tap placed at the lower part of the boiler. A certain quantity of tar obstinately retains the water, constituting a buttery matter, which may be allowed to run away with the water, to be added afterwards to another quantity of tar, to be dehydrated by a fresh operation.

Experience seems to have demonstrated that the most simple process, that is to say, distillation over a naked fire at the ordinary pressure, is still the most practicable and advantageous. As the volatile products have but little latent heat, the height of the still should be somewhat less than the diameter; for the same reason the head must be carefully protected from cold, and it is well to furnish the inside with a circular gutter, in which the products condensed in the head may be collected and run into the refrigerator. By this means the

products are prevented from flowing back into the boiling tar and being decomposed by coming in contact with the sides of the still, which, especially towards the end of the operation, become very hot.

In condensing the vapors it is necessary to observe certain precautions. At the beginning of the operation, when the lighter and more volatile oils are passing, the worm must be well cooled to make quite sure of the condensation. Later, when the heavier and less volatile products are coming over, the water in the refrigerator may be allowed to get heated to 30° or 40°, and at last when the matters capable of solidifying, such as naphthaline and paraffine, pass, the temperature of the refrigerator should never be under 40°, and it may be allowed without inconvenience to rise to 60° or 70°. At this temperature the products condense perfectly, but remain liquid and run with ease. If the refrigerator were kept quite cold during the whole process, it might happen towards the end that the condensing tube would become blocked up by the solidified products, and a dangerous explosion might ensue.

At the beginning of the distillation the tar should not be allowed to boil too fast. Some distillers at this period pass a current of steam at 110° or 120° through the tar, to assist the disengagement of the more volatile oils. These in condensing form a limpid very fluid liquid, having the density ·780, which gradually rises to ·850; the mean density of all the products united is about ·830. It is this which constitutes the benzine of commerce. It contains a great variety of compounds whose boiling points range from 60° to 200°. They belong principally to the following series:—Cn Hn *e.g.* Amylene $C_5 H_5$; Hexylene (Oleene, Caproylene), $C_6 H_6$; Heptylene (Oenenthylene), $C_7 H_7$, &c. Cn Hn + 2 *e.g.* Propyle $C_{12} H_{14}$; Butyle, $C_{16} H_{18}$; Amyle, $C_{20} H_{22}$, &c. Cn Hn — 6 *e.g.* Benzine, $C_{12} H_6$, &c.

When the density of the products exceeds 850°, the current of steam is stopped and the heat is increased. As soon as the temperature of the tar has risen to 200°—220°, the distillation recommences, and the oil condensed is found to have the sp. gr. ·860—·900, the mean being from ·880 to ·885. This product constitutes the heavy oil of tar, and contains phenol, creosote, and aniline.

Lastly, the ultimate products of the distillation, which on cooling become a buttery mass (or crystalline, if they contain much naphthaline), are set aside for the preparation of paraffine. They are placed in vats, which are cooled, in order that the solid matters may separate by crystallization.

According to Payen, 2000 parts of rough oil or tar obtained by the distillation of boghead coal furnish on rectification:

1208 parts	light oil, density,	·825
200 "	heavy oil, "	·860
400 "	pitch.	

The loss of 200 parts represents the gases, and the vapors and oils which have escaped. 2900 parts of tar from gas works using boghead coal, distilled in a similar manner, yielded:

Water, slightly ammoniacal,		168 parts.
Light hydrocarbons, mean density	·820	480 "
Heavy " "	·863	883 "
Fatty pitch, solid when cold, liquid at 150°		1195 "
Loss six per cent.,		174 "
		2900 "

(To be Continued.)

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 104.)

Table showing the breaking weight of hollow cylindrical pillars for different qualities of cast iron, both ends being flat and firmly fixed.

The formulæ for the breaking weight by which the following table for hollow pillars, and a preceding similar one for solid pillars, were calculated, are as under :

For the solid pillars,

$$\mathrm{W} = m \times \frac{\mathrm{D}^{3.55}}{\mathrm{L}^{1.7}}.$$

For the hollow pillars,

$$\mathrm{W} = m \times \frac{\mathrm{D}^{3.55} - d^{3.55}}{\mathrm{L}^{1.7}}.$$

m representing a weight varying from 78,400 lbs. to 134,400 lbs., the higher ones being used as examples only.

The co-efficients given by Mr. Hodgkinson are of course not applicable for the strength of all cast iron, therefore the weight must vary according to the strength of the material.

Height of Pillar in feet.	Number of diams. contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Co-efficients for the strength, in lbs.					
				78,400	89,600	100,800	112,000	123,200	134,400
				Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
8	48	2	1	10·93	12·49	14·05	15·61	17·17	18·74
10	60	2	1	7·48	8·55	9·61	10·68	11·75	12·82
10	40	3	2	26·32	30·08	33·84	37·60	41·36	45 12
12½	50	3	2	18·01	20·58	23·15	25·73	28·30	30·87
12½	37½	4	3	41·95	47·94	53·93	59 92	65 92	71·91
15	45	4	3	30·77	35·16	39 56	43 95	48·35	52·74
15½	37 1-5	5	4	54·94	62·79	70·64	78·49	86·33	94 18
17	40 4-5	5	4	46·95	53·66	60·37	67·08	73·79	80·50
17½	35	6	5	74·37	84·99	95·62	106 24	116 87	127·49
20	40	6	5	59 26	67·73	76·14	84·66	93·13	101·60

Hollow Cylindrical Pillars for different qualities of Cast Iron, Both Ends being Flat and Firmly Fixed.

Height of Pillar in feet	Number of diams. contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Value of b in tons from formula, $b = 44{\cdot}34 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.	Value of c, in tons.	Breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.
15	30	6	5	122·45	381·86	114·36
15	30	6	5	122·45	423·33	117·82
15	30	6	5	122·45	477·32	121·65
				$b = 40{\cdot}00 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	110·46	381·86	106·28
				$b = 50{\cdot}00 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	138 08	477·32	132·86
				$b = 42{\cdot}347 \frac{D^{3.5} - d^{3.5}}{L^{1.63}}$.		
15	30	6	5	127·93	381·86	117·90
15	30	6	5	127·93	423·33	121·58
15	30	6	5	127·93	477·32	125·66
				$b = 46{\cdot}65 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	128·83	381·86	118·47
15	30	6	5	128·83	423·33	122·19
15	30	6	5	128·83	477·32	126·31
				$b = 35\ 00 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	96·65	334·08	92·99

Mr. Hodgkinson found that the weight which would crush the pillars if they were very short, would vary as 5 to 9 nearly, and for long flexible pillars he found the weight varied from 49·94 tons, in the strongest iron he tried, to 33·60 tons in the weakest. Therefore, if we take the case of a hollow cylindrical pillar, of 6 inches external diameter and 5 inches internal diameter, beginning at 10 diameters or 5 feet high, the co-efficient for the strength will be 16·91 tons, for 6 feet high 20·88 tons, for 7 feet high 24·56 tons, for 8 feet high 27·84 tons, and so on, increasing till we arrive at 44·34 tons, or a trifle above 16 feet or 32 diameters. And in the case of a solid pillar of the same height and 6 inches diameter, the co-efficient for the strength will be 22·69 tons, increasing in a similar manner as in the above, till we arrive at 44·16 tons, or about $12\frac{1}{2}$ feet or 25 diameters.

At page 309, vol. xli, of this Journal, I remarked that the breaking weight of pillars is not critically correct for pillars with flat ends whose height is only 30 diameters; I should there have expressed it as applying only to hollow ones, as the nearer we approach to a solid the farther we recede below 30 diameters, approaching nearer and nearer to 25 diameters, as in the solid pillars with flat ends, as will be seen by inspection of the following table for a hollow pillar, 15 feet high, and 6 inches external diameter. It is also made plain by this table, that a hollow pillar, 15 feet high, 6 inches external diameter, and whose sectional thickness is 2 inches, will support very nearly the same weight as a solid one of the same height and 6 inches diameter, with a saving in the weight of metal of 147·41 lbs.; that is, that 1179·37 lbs. will support as a hollow cylinder nearly as great a weight as a solid one containing 1326·78 lbs.; the safe weight of the former being 62·94 tons, and that of the latter 63·98 tons.

Table referred to in the above.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Value of b in tons from formula, $b = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$.	Value of c, in tons.	Value of Y in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.	Breaking weight in tons.
15	30	6	5	405·40	122 45	423·33	117·82	117·82
"	"	6	4½	578·94	164·42	606·23	161·00	161·00
"	"	6	4	737·10	196 04	769 69	195·12	195·12
"	"	6	3½	875·31	219 04	914 00	221·33	219·04
"	"	6	3	995·10	235·03	1039 08	240·76	235 03
"	"	6	2	1179·37	251·76	1231·50	263·77	251·76
"	"	6		1326·78				

Breaking weight of solid pillar in tons from formula $W = 44{\cdot}16 \frac{D^{3\cdot55}}{L^{1\cdot7}}$, 255·92.

The following table will show a few hollow pillars of different dimensions having a corresponding breaking weight as the pillar referred to above; also, the safe weight of each, and their weight of metal.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Weight of metal.	Breaking weight in tons.	Safe weight in tons.
10	6	4½	385 96	253 86	63·46
14	7	5½	643·24	250·23	62·55
18	8	6½	961·93	253·67	63·41
22½	9	7½	1368 26	253·79	63 44
27	10	8½	1840 94	254·44	63·61
12	6	4	589·68	255·29	63·82
16½	7	5	972 98	254·39	63·59
21¼	8	6	1461·93	252·54	63·13

I shall not in this series give any further tables for cast iron pillars with rounded ends, conceiving it sufficient for all practical purposes to assume one-ninth or one-tenth of the breaking weight of pillars with flat ends as a correct approximation for the safe weight if irregularly fixed, imperfectly set, or not truly perpendicular.

At page 307, vol. xli, I gave a table for pillars whose heights were less than 31 diameters with rounded ends, and, as I have omitted similar pillars with flat ends of the same dimensions, that should have preceded those with rounded ends, I introduce the following table to supply the deficiency.

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34 \frac{D^{3 \cdot 55} - d^{3\cdot 55}}{L^{1 \cdot 7}}$ $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	24	4	2	235 87	147·30	36·82	14·73
9½	28 1-2	"	"	280·09	119·65	29·91	11 96
10	30	"	"	294 84	111·01	27·75	11·10
8	19 1-5	5	3	314 49	255 60	63 90	25 56
10	24	"	"	393 12	201·29	50·32	20·12
12	28 4-5	"	"	471·74	161·74	40·43	16·17
8	16	6	4	393·12	382·66	95·66	38·26
10	20	"	"	491·40	310 61	77·65	31·06
12	24	"	"	589·68	255·29	63 82	25 52
14	28	"	"	687·96	212·69	53·17	21·26
15	30	"	"	737·10	195 12	48·78	19·51
10	17 1-7	7	5	589·69	435·06	108 76	43·50
12	20 4-7	"	"	707·62	364 93	91 23	36·49
14	24	"	"	825·56	308·93	77·23	30·89
15	25 5-7	"	"	884·53	285·31	71·32	28·53
16	27 3-7	"	"	943 50	264·14	66·03	26 41
16½	28 2-7	"	"	972·98	254·39	63·59	25·43
12	18	8	6	825·56	487·28	121·82	48·72
14	21	"	"	963·15	418 58	104·64	41·85
15	22 1-2	"	"	1031·95	388·98	97·24	38 89
16	24	"	"	1100·75	362·14	90·53	36 21
18	27	"	"	1238 34	315·68	78 92	31·56
20	30	"	"	1375·94	277·22	69·30	27·72
14	16 4-5	10	8	1238·34	668·65	167·16	66·86
15	18	"	"	1326 79	628·21	157 05	62 81
16	19 1-5	"	"	1415·24	590·77	147·69	59 07
18	21 3-5	"	"	1592·15	524 13	131 03	52·41
20	24	"	"	1769·06	467·15	116·78	46·71
15	15	12	10	1621·63	898·08	224·52	89·80
16	16	"	"	1729·74	851·69	212·92	85 16
18	18	"	"	1945·96	767·17	191·79	76·71
20	20	"	"	2162 18	692·82	173·20	69·28
22	22	"	"	2378 39	627·60	156·90	62·76
25	25	"	"	2702·72	544·44	136·11	54·44
30	30	"	"	3243·27	436·76	109·19	43·67

Mr. Henry Law informs us that the following formula is Mr. Hodg-

kinson's for the strength of a hollow cylindrical column of wrought iron with both ends flat, when the height of the column is not less than 30 times its diameter:

$$W = 77{\cdot}2 \frac{D^{3.6} - d^{3.6}}{L^{1.7}};$$

and Mr. Jos. W. Sprague in an article advocating his wrought iron bridge truss, says that "Hodgkinson's formula for the value of W in tons, is

$$W = 133{\cdot}75 \frac{D^{3.55} - d^{3.55}}{L^2},$$

when the length of the column exceeds thirty times its diameter."

Up to the present I have not been able to discover that either of the above formulæ has emanated from Mr. Hodgkinson; but, as an example, I give below the result of my calculations deduced from each of them.

Table comparing the Strength of Hollow Cylindrical Pillars of Wrought Iron, by the formulæ above referred to.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated breaking weight in tons from formula, $W = 77{\cdot}2 \frac{D^{3.6} - d^{3.6}}{L^{1.7}}$.	Calculated breaking weight in tons from formula, $W = 133{\cdot}75 \frac{D^{3.55} - d^{3.55}}{L^2}$.
$17\frac{1}{2}$	35	6	5	181·20	120·42
20	40	"	"	144·40	92·20
20	40	"	$5\frac{1}{2}$	80·68	51·42
$17\frac{1}{2}$	35	"	"	101·25	67·16

There are so many considerations requisite, and all of them likely to lead to complicated results, that I shall make no attempt to form a table for the strength of hollow cylindrical pillars of wrought iron.

Tables showing the calculated breaking weight and safe weight of uniform solid cylindrical pillars of wrought iron, and the calculated weight of metal contained in each pillar.

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diams. contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formula, $W = 133{\cdot}75 \frac{D^{3.55}}{L^2}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	30	2	53·07		54·14	13·53	5·41
6	36	"	63·68	43·51		10·87	4·35
7	42	"	74·29	31·97		7·99	3·19
8	48	"	84·91	24·47		6·11	2·44
9	54	"	95·52	19·34		4·83	1·93

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 133{\cdot}75 \frac{D^{3{\cdot}55}}{L^2}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	60	2	106·14	15·66		3 91	1·56
11	66	"	116·75	12·94		3·23	1·29
12	72	"	127·36	10·87		2·71	1·08
13	78	"	137 98	9·26		2·31	0·92
14	84	"	148·59	7·99		1·99	0·79
15	90	"	159 21	6·96		1·74	0·69
16	96	"	169·82	6·11		1·52	0·61
17	102	"	180·48	5·42		1·35	0·54
18	108	"	191·05	4·83		1·20	0·48
19	114	"	201·66	4 33		1·08	0·43
20	120	"	212·28	3·91		0·97	0·39
5	24	2½	82·92		104·39	26·09	10·43
6	28·8	"	99·51		83·58	20·89	8·35
7	33·6	"	116·09	70·59		17·64	7·05
8	38·4	"	132·68	54·04		13·51	5·40
9	43·2	"	149·26	42·70		10·67	4·27
10	48	"	165·85	34·59		8·64	3·45
11	52·8	"	182·43	28·58		7·14	2·85
12	57·6	"	199·02	24·02		6·00	2·40
13	62·4	"	215·60	20·46		5·11	2·04
14	67·2	"	232·19	17·64		4·41	1·76
15	72	"	248·77	15·37		3·84	1·53
16	76·8	"	265·36	13·51		3·37	1·35
17	81·6	"	281·94	11·96		2·99	1·19
18	86·4	"	298·53	10·67		2·66	1·06
19	91·2	"	315 11	9·58		2·39	0·95
20	96	"	331·70	8·64		2·16	0·86
5	20	3	119 42		174·67	43·66	17·46
6	24	"	140·30		143·40	35·85	14·34
7	28	"	167·18		118·35	29 58	11·83
8	32	"	191·07	98·49		24·62	9·84
9	36	"	214·95	81·44		20·36	8·14
10	40	"	238·84	66·07		16·51	6·60
11	44	"	262·72	54·60		13·65	5·46
12	48	"	286·60	45·88		11·47	4·58
13	52	"	310·49	39·09		9·77	3·90
14	56	"	334 37	33·71		8·42	3·37
15	60	"	358·26	29·36		7·34	2·93
16	64	"	382·14	25·80		6·45	2·58
17	68	"	406·02	22·86		5·71	2·28
18	72	"	429·91	20·39		5·09	2·03
19	76	"	453·79	18·30		4·57	1·83
20	80	"	477 68	16·51		4·12	1·65
5	17·142	3½	162·55		265·75	66·43	26·57
6	20·571	"	195·06		222·95	55·73	22·29
7	24	"	227·57		187·30	46·82	18·73
8	27·428	"	260·08		158·12	39·53	15 81
9	30·857	"	292·59		134·40	33·60	13·44

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formula, $W = 133\cdot75 \frac{D^{3\cdot55}}{L^2}$.	Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	34·285	$3\frac{1}{2}$	325·10	114·21		28·55	11·42
11	37·714	"	357·61	94·39		23·59	9·43
12	41·142	"	390·12	79·31		19·82	7·93
13	44·571	"	422·69	67·58		16·89	6·75
14	48	"	455·14	58·27		14·56	5·82
15	51·428	"	487·65	50·76		12·69	5·07
16	54·857	"	520·16	44·61		11·15	4·46
17	58·284	"	552·67	39·52		9·88	3·95
18	61·714	"	585·18	35·25		8·81	3·52
19	65·142	"	617·69	31·63		7·90	3·16
20	68·571	"	650·20	28·55		7·13	2·85
5	15	4	212·30		377·93	94·48	37·79
6	18	"	254·76		323·04	80·76	32·30
7	21	"	297·22		275·71	68·92	27·57
8	24	"	339·68		235·84	58·96	23·58
9	27	"	382·14		202·63	50·65	20·26
10	30	"	424·60		175·08	43·77	17·50
11	33	"	467·06	151·64		37·94	15·16
12	36	"	509·52	127·42		31·85	12·74
13	39	"	551·98	108·57		27·14	10·85
14	42	"	594·44	93·61		23·40	9 36
15	45	"	636·90	81·55		20·38	8·15
16	48	"	679·36	71·67		17·91	7·16
17	51	"	721 82	63·49		15·87	6·34
18	54	"	764·28	56 63		14·15	5·66
19	57	"	806·74	50·82		12·70	5·08
20	60	"	849·20	45·87		11·46	4·58
5	13·333	$4\frac{1}{2}$	268·70		511·27	127·81	51·12
6	16	"	322·44		444·07	111·01	44·40
7	18·666	"	376·18		384·36	96·09	38·43
8	21·333	"	429·92		332·74	83·18	33·27
9	24	"	483·66		288·78	72·19	28·87
10	26·666	"	537·40		251·63	62·90	25·16
11	29·333	"	591·14		220·30	55·07	22·03
12	32	"	644·88	193·56		48·39	19·35
13	34·666	"	698·62	164·93		41·23	16·49
14	37·333	"	752·36	142·21		35·55	14·22
15	40	"	806·10	123·88		30·97	12·38
16	42·666	"	859·84	108·88		27·22	10·88
17	45·333	"	913·58	96·44		24·11	9·64
18	48	"	967·32	86·02		21·50	8·60
19	50·666	"	1021·06	77·21		19·30	7·72
20	53·333	"	1074·80	69·68		17·42	6·96
5	12	5	331·75		665·71	166·42	66·57
6	14·4	"	398·10		586·24	146·56	58·62
7	16·8	"	464·45		513·76	128·44	51·37
8	19·2	"	530 80		449·62	112·40	44·96
9	21·6	"	597·15		393·89	98·47	39·38

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formula, $W = 133{\cdot}75 \frac{D^{3\cdot55}}{L^2}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	24	5	663·50		345·96	86·49	34·59
11	26·4	"	729·85		304·95	76·23	30·49
12	28·8	"	796·20		269·90	67·47	26·99
13	31·2	"	862·55	239·74		59·93	23·97
14	33·6	"	928·90	206·71		51·67	20·67
15	36	"	995·25	180·07		45·01	18·00
16	38·4	"	1061·60	158·26		39·56	15·82
17	40·8	"	1127·95	140·19		35·04	14·01
18	43·2	"	1194·30	125·05		31·26	12·50
19	45·6	"	1260·65	112·23		28·05	11·22
20	48	"	1327·00	101·29		25·32	10·12
5	10	6	477·70		1037·28	259·32	103·72
6	12	"	573·24		934·01	233·50	93·40
7	14	"	668·78		835·68	208·92	83·56
8	16	"	764·32		745·16	186·29	74·51
9	18	"	859·86		663·69	165·92	66·36
10	20	"	955·40		591·42	147·85	59·14
11	22	"	1050·94		527·89	131·97	52·78
12	24	"	1146·48		472·31	118·07	47·23
13	26	"	1242·02		423·82	105·95	42·38
14	28	"	1337·56		381·51	95·37	38·15
15	30	"	1433·10	343·98		85·99	34·39
16	32	"	1528·64	302·33		75·58	30·23
17	34	"	1624·18	267·81		66·95	26·78
18	36	"	1719·72	238·88		59·72	23·88
19	38	"	1815·26	214·39		53·59	21·43
20	40	"	1910·80	193·52		48·38	19·35

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	8	12	$10\frac{1}{2}$	663·40	1003·66	250·91	100·36
9	9	"	"	746·32	955·46	238·86	95·54
10	10	"	"	829·25	908·30	227·07	90·83
11	11	"	"	912·17	862·65	215·66	86·26
12	12	"	"	995·10	818·78	204·69	81·87
13	13	"	"	1078·02	776·89	194·22	77·68
14	14	"	"	1160·95	737·10	184·27	73·71
15	15	"	"	1243·87	699·44	174·86	69·94
16	16	"	"	1326·80	663·89	165·97	66·38

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
17	17	12	$10\frac{1}{2}$	1409·72	630·42	157·60	63·04
18	18	"	"	1492·65	598·96	149·74	59 89
19	19	"	"	1575·57	569·41	142·35	56·94
20	20	"	"	1658 50	541·68	135·42	54·16
21	21	"	"	1741·42	515 67	128·91	51·56
22	22	"	"	1824 35	497·67	124·41	49·76
23	23	"	"	1907·27	468·42	117·10	46·84
24	24	"	"	1990·20	446·98	111·74	44·69
25	25	"	"	2073·12	426·86	106·71	42·68
26	26	"	"	2156·05	407·97	101·99	40·79
27	27	"	"	2238·97	390·28	97·57	39·02
28	28	"	"	2321·90	373·56	93·39	37·35
29	29	"	"	2404 82	357·88	89·47	35·78
30	30	"	"	2487·75	343·13	85·78	34·31
8	7 5-13	13	$11\frac{1}{2}$	722·36	1124·08	281·02	112·40
9	8 4-13	"	"	812·66	1075·17	268 79	107·51
10	9 3-13	"	"	902·96	1026·87	256·71	102 68
11	10 2-13	"	"	993·25	979·67	244·91	97·96
12	11 1-13	"	"	1083·55	933·92	233·48	93·39
13	12	"	"	1173·84	889 86	222·46	88·98
14	12 12-13	"	"	1264·14	847·66	211·91	84·76
15	13 11-13	"	"	1354·44	807·40	201·85	80·74
16	14 10-13	"	"	1444·73	769·13	192·28	76·91
17	15 9-13	"	"	1535·03	732 83	183·20	73 28
18	16 8-13	"	"	1625·32	698·50	174·62	69·85
19	17 7-13	"	"	1715 62	666·04	166·51	66·60
20	18 6-13	"	"	1805·92	635·40	158·85	63·54
21	19 5-13	"	"	1896·21	606·52	151·63	60·65
22	20 4-13	"	"	1986 51	579·29	144·82	57·92
23	21 3-13	"	"	2076·80	553·63	138·40	55 36
24	22 2-13	"	"	2167·10	529·46	132·36	52·94
25	23 1-13	"	"	2257·40	506·69	126·67	50·66
26	24	"	"	2347·69	485·21	121·30	48·52
27	24 12-13	"	"	2437 99	464·97	116·24	46·49
28	25 11-13	"	"	2528·28	445·88	111·47	44·58
29	26 10 13	"	"	2618·58	427·87	106·96	42·78
30	27 9-13	"	"	2708 88	410·87	102·71	41·08

(To be Continued.)

Magnetic Phenomenon.

From the Lond. Ed. and Dub. Phil. Mag., October, 1860.

M. Ruhmkorff has the following notice in the *Comptes-Rendus*, vol. l, p. 166:—"If a stay (*bride*) of soft iron be pressed against one of the poles of an artificial magnet, the soft iron is observed to become hard, and it is more difficult to file. If the stay be removed, it loses its hardness and resumes all the properties of soft iron."

On White Gunpowder. By M. Pohl.

From the Lond. Edin. and Dub. Phil. Mag., July, 1861.

Pohl has communicated* a research on the white gunpowder invented by Augendre, which consists of prussiate of potash, white sugar, and chlorate of potash. Pohl finds that the following mixture gave a very good burning powder:—

Prussiate of potash, .	28 parts.
Sugar, . .	23 "
Chlorate of potash, .	49 "
	100

which is very nearly in the relation

$$K^2 Cfy, 3HO + C^{12} H^{11} O^{11} + 3KO\,Cl\,O^5.$$

Of the products formed by the combustion of this powder, it would be difficult to state any thing with accuracy without very numerous analyses, and they would differ according as the combustion was free or in a closed space, and whether it was slow or rapid. Assuming that the possible products of decomposition of the ferrocyanide are nitrogen, cyanide of potassium, and a carbide of iron of the formula FeC^2, the decomposition might be represented in the following manner:—

$$K^2 Fe\,Cy^3 + C^{12} H^{11} O^{11} + 3(KO\,Cl\,O^5) = 2K\,Cy + 3K\,Cl + Fe\,C^2 + N$$
$$+ 6CO + 6CO^2 + 14HO;$$

according to which 100 parts of the powder would yield 52·56 parts of non-volatile, and 47·44 of gaseous substances.

The decomposition may take place in conformity with other reactions, but from a preliminary investigation this appears the most probable.

In accordance with this, 100 parts of the powder would yield—

Nitrogen, . . .	1·86
Carbonic oxide, . .	11·19
Carbonic acid, . .	17·59
Water, . . .	16·79
	47·43

and

Cyanide of potassium, .	17·38
Chloride of potassium, .	29 84
Carbide of iron, . .	5·33
	52·55

hence, reduced to volumes at 0° and 760 millims., 100 parts would yield—

Nitrogen, .	1927	cub. centims.
Carbonic oxide,	8943	"
Carbonic acid, .	8943	"
Aqueous vapor,	20867	"
	40680	"

* *Sitzungsberichte der Wiener Akademie*, vol. xli.

Pohl calculates from this that the quantity of heat furnished by the combustion of this substance would be equal to 506·3 thermal units. The temperature of the combustion is obtained by dividing the number of thermal units by the sum of the specific heats of the products of combustion, which amounts to 0·2636; and this gives 1920° C. as the temperature. From Bunsen and Schischkoff's research,* it appears that the heating effect of ordinary gunpowder is 619·5 thermal units, and that the temperature of its free combustion is 2993° C. It furnishes in 100 parts, 68·06 of solid residue, and 31·38 of gaseous products, corresponding to 19,310 cubic centims. From these data, the relation between the two substances is—

	Black powder.		White powder.
The quantity of gas,	1	:	2·107
The temperature of flame,	1	:	0·641
The residues,	1	:	0·77

But for the respective temperatures of combustion the reduced volumes of gas would be, for black powder, 231,411 cubic centims., and, for white powder 300,798 cubic centims., and hence the quantities of gas would be as 1 : 1·13.

In the combustion in a confined space, the temperature of the combustion would be altered, for there would be a great difference in the specific heat of the products of combustion. Hence, the volume of gas, when reduced to the normal temperature and pressure, would vary. For white gunpowder, Pohl calculates the temperature of combustion in a closed space at 2604° C., and the volume of gas furnished by 100 parts at 431,162 cubic centims. Under similar circumstances Bunsen and Schischkoff found that the temperature was 3340° C., and the volume of gas 258,420 cubic centims.

Hence, the relation between the products of combustion in confined space would be—

	Black powder.		White powder.
The temperature of the flames,	1	:	0·779
The volumes of gas,	1	:	1·669

As the action of an explosive powder principally depends on the volume of the gases formed, for equal weights the new white powder would produce 1·67 times the action of the other. But for equal volumes of the powder the ratio would be different. Pohl found that a vessel which held 102·542 grms. of white powder, held 132·355 grms. of ordinary black powder. Hence, the density of the new powder in reference to the other would be as 0·774 : 1, and the work performed by equal volumes would be as 1·292 : 1.

In order to produce the same effect on projectiles, in firing mines, &c., 60 parts by weight of the new, would be required for 100 parts of the old. The weights of the residues in the two cases are respectively 31·53 and 68 parts. Another advantage of the white powder is, that the temperature of the flame is much lower; a greater number of shots could be fired without heating the projectile too much. The new powder is more energetic in its action than the old, and in

*Phil. Mag., vol. xv, p. 489.

this respect stands nearest gun-cotton. It has the advantage over this substance of being cheaper and easier to prepare, and it can be kept for a long time without undergoing any change.

The new powder contains chlorate of potash; and this, in all substitutes for gunpowder of which it is a constituent, forms products of combustion at a high temperature, which attack the fire arms. If the decomposition of the white powder takes place in accordance with the equation already given, it is not easy to see why this evil is to be feared. It could be most simply decided by firing off a certain number of shots with a given weapon. Another advantage of the new powder is its difficult explosibility by pressure and percussion. Explosion is only produced by the heaviest blow of iron upon iron; it is not produced by the friction of wood upon metal, or between stones, &c. The new powder is also far easier of preparation than the old; and if the raw materials are at hand, a large quantity of it may be prepared in a few hours with no other apparatus than a stamping-mill and mixing tub.

Some Results of the Census of 1861.

From the London Builder, No. 958.

By the exertions made at the Census Office, we are enabled to obtain some idea of the population of England on the 8th of April last; for, although the returns recently made by the Registrar-General from the books of the 631 superintendent registrars of England have not yet been fairly tested at the Census Office, it is not apprehended that the alterations, which a careful revision of the original documents may render necessary, will be of importance sufficient to lessen the value of the figures as materials for whatever general inferences may fairly be drawn from them.

In first glancing at these figures, it is important to notice that the decennial rates of increase have declined since the ten years from 1811 to 1821, and have up to 1861 been steadily on the decrease, as will be seen by an examination of the following figures:—

	Population of England.	Increase.	Decennial Rate of Increase.
1801	9,156,171		
1811	10,454,529	1,298,358	14 per cent.
1821	12,172,644	1,718,135	16 "
1831	14,051,986	1,879,322	15 "
1841	16,035,198	1,983,212	14 "
1851	18,054,170	2,018,972	13 "
1861	20,223,746	2,169,576	12 "

The cause of this decrease in the decennial rate of the population is a matter which calls for very careful inquiry; we therefore look anxiously forward to those details of the Census returns which will

be likely to show the cause of a decline which is not to be attributed to increased death-rates; for it is certain that the average duration of human life, in the chief districts of both town and country, has, by means of sanitary and other improvements, been materially increased; nor is the decrease to be accounted for by the extent of the emigration from England; for the returns of the Emigration Commissioners show that, in the interval between March 31st, 1851, and April 8th, 1861, 2,249,355 emigrants sailed from the ports of the United Kingdom. But of this number, probably 194,522 were of foreign origin; leaving 2,054,823 emigrants from the population of the United Kingdom; of whom only about 640,210 were of English origin, 183,627 were of Scotch origin, and 1,230,986 were of Irish origin.

Notwithstanding the decline in the decennial rates, it is satisfactory to find that in the last ten years 2,169,576 have been added to the population of England;* and to compare our condition in this respect with that of about the middle of the last century, when it was the practice to subsidize foreign troops for the defence of the nation and for the preservation of order. From the Peace of Utrecht down to 1740, the numbers of the English people had actually declined; and in 1756, by a grant of the Parliament, a large body of Hanoverians and Hessians arrived on our shores.

From 1751 to 1772, after the passing of Lord Hardwick's Marriage Act, the increase of the population became more satisfactory. This is partly to be attributed to the improved habits of the people, the increase of well-constituted families, and the great increase of the industry of Great Britain.

The manufacture of iron by wood-charcoal in England rapidly declined; until at length, in the year 1740, the produce fell to 17,350 tons. Coal was tried, and, after that time, was successfully used for smelting; so that, in 1788, the produce was *seventy thousand tons;* in 1800, a *hundred and eighty thousand tons;* and in the year 1851, two millions five hundred thousand tons. Iron and steel tools have been placed in the hands of the workmen and laborers of the country, —arms in the hands of the army and navy.

After 1751, agriculture advanced rapidly. Lord Townsend introduced the turnip-culture from Germany, with important results. Many of the landed proprietors, instead of drowning their senses in drink, wasting their time in intrigues, or squandering their estates in gambling, devoted themselves to the encouragement of societies of agriculture: the farmers adopted new processes; the increased produce of the farms was improved in quality: marshes were drained; machinery introduced; the breeds of various domestic animals decidedly improved; and an impulse given to the cultivation of the finest part of agricultural science, which is intimately related to the science of population, and will in the end throw much light on its principles.

New roads were made and old ones improved; and canals for the transport of wood, coal, goods, and general produce, were commenced

* We have no returns yet for Scotland and Ireland.

by the enlightened spirit of Bridgewater, who, with the aid of Brindley's genius, triumphed over engineering difficulties which in those days were held insuperable. New machines were invented, and new employments brought into use.

Josiah Wedgwood, the potter, produced (1763) a new kind of earthenware; Paul or Wyatt first, and then Arkwright, the barber, invented a spinning-jenny in 1767; Hargreaves, a weaver, took out the patent for his spinning-jenny in 1770; and the mule was completed by Compton, also a weaver, in 1787. James Watt placed the force of steam at man's disposal. By other eminent men, a thousand different means have been produced, yielding in value millions sterling yearly, and so offering occupation and subsistence to the population; and, since 1830, the railroads, with steam and sailing vessels, have placed the population in direct and easy communication, not only with each other in Great Britain, but with the rest of the world.

The circumstances of our times disprove the theory of Malthus and the supporters of his ideas, for they show that, although the population has doubled in a period of about fifty-three years, employment is more plentiful, and the necessaries of life more easily to be obtained, than when the number of the people in the land was comparatively small.

The population of the metropolis in April, 1861, is given at 2,803,034, as against 2,362,236 in 1851: increase in ten years, 440,788; average per year, 44,078·8. And it may be useful here to give the increase of the population of the London district since 1801:—

	Population.	Increase in ten years.	Increase per year.
1801	958,863		
1811	1,138,815	179,922	17,995·2
1821	1,378,947	240,132	24,013·2
1831	1,654,994	276,047	27,604·7
1841	1,984,417	329,423	32,942·3
1851	2,362,236	377,819	37,781·9
1861	2,803,034	440,798	44,079·4

In the thirty-seven districts into which the area of the metropolis is divided, ten have decreased in population, viz:—

	1851.	1861.	Decrease.
St. Martin's-in-the-Fields, . .	24,640	22,636	2,004
St. James's, Westminster, . .	36,406	35,324	1,082
St. Giles's, ...	54,214	53,981	233
Strand, ...	44,417	42,956	1,461
Holborn, ...	46,621	44,861	1,760
East London, ...	44,406	40,673	3,733
West London, ...	28,833	27,144	1,688
London City, ...	55,932	45,550	10,382
Whitechapel, ...	79,759	78,963	796
St. Olave's, Southwark, . .	19,375	19,053	322

It will thus be seen that, during the last ten years, nearly one-fifth of the population of London City has been removed; that there is a marked decrease in the numbers in East London, West London, the Strand, and Holborn; the decrease in St. Giles's, Whitechapel, and St. Olave's, being small in comparison.

The following shows the increase of the other districts:—

	Population, 1851.	Population, 1861.	Increase.
Kensington, . . .	120,004	186,463	66,459
Chelsea, . . .	56,538	63,423	6,885
St. George's, Hanover-square, .	73,230	87,747	14,517
Westminster, . . .	65,609	67,676	2,067
Marylebone, . . .	157,696	161,609	3,913
Hampstead, . . .	11,986	19,104	7,118
Pancras, . . .	166.956	198.882	31,296
Islington, . . .	95.329	155,291	59,962
Hackney, . . .	58,429	83,295	24,866
Clerkenwell, . . .	64,778	65.632	854
St. Luke's, . . .	54,055	56.697	2,942
Shoreditch, . . .	109,257	129,339	20,082
Bethnal-green, . . .	90,193	104,905	14,712
St. George's-in-the-East, .	48.376	48,876	502
Stepney, . . .	54,173	56,567	2,394
Mile-end Old Town, . .	56,602	73,064	16,462
Poplar, ...	47,162	79,182	32,020
St. Saviour's, Southwark, .	35,731	36,026	295
Bermondsey, . . .	48,128	58,355	10,227
St. George's, Southwark, .	51,824	55.509	3,685
Newington, . . .	64,816	82,157	17,341
Lambeth, . . .	139,325	162,008	22,683
Wandsworth, . . .	50,764	71,489	16.822
Rotherhithe, . . .	17,805	24,500	6,695
Greenwich, . . .	99,365	127.662	28,297
Lewisham, . . .	35,835	65,752	30,917

We thus see that the greatest increase of the London district has been—first in Kensington, second in Islington, third in Poplar, fourth in Pancras, fifth in Lewisham, sixth in Greenwich, seventh in Hackney and Hampstead. Then follow Lambeth, Shoreditch, Mile-end Old Town, Bethnal-green, &c., &c.

While this immense increase is going forward in the suburban neighborhoods, the old parts of London, as regards their population, have either decreased or have remained during the last ten years nearly stationary. In Clerkenwell, with a population of upwards of 65,000, there has been only an increase of 854; in Westminster, with a population of over 67,000, an increase of 2067; Marylebone, population of more than 161,000, an increase of 3913; St. Saviour's, Southwark, population upwards of 36,000, an increase only of 502. The peculiarities of the metropolitan population may be attributed to various causes, amongst which may be mentioned the conversion of the central parts of the City into places of business, the facilities afforded by omnibus, steam-packet, and railway conveyance, to and from the

suburbs; there is also the demolition of dwellings in some localities. To this important matter we will take an opportunity of carefully referring, too, as soon as we have the exact figures of the number of the inhabitants, and the number of the dwellings in each district.

Taking the whole of the metropolitan district, in 1851 the population was 2,362,236; the number of inhabited houses, 305,933. This gives an average of $7\frac{220,705}{305,933}$ persons in each house. In April, 1861, the population was 2,803,034; the number of houses, 362,890. The average number of inhabitants of each house, $7\frac{262,804}{362,890}$. We thus find that, upon the whole, in London there has been a very slight increase of overcrowding in dwellings.

From this we can form but little idea of the unwholesome overcrowding of certain localities. When, however, more details come to hand, we trust that, by the help of them and by some personal observation, we shall be able to throw some useful light upon the changing features of the metropolis.

In 1841, the average number of persons to each inhabited house throughout England and Wales was 5·4, instead of 7·4 in the London division.

During the ten years above referred to, 56,957 inhabited houses have been added to this monster city; this is at the rate of rather more than five thousand six hundred and ninety-five in each year. This is a vast amount of new work to be added to the houses which have been rebuilt or altered during this period.

The periodical taking of the census is a laborious and expensive affair, but the value of the result is great. On the last occasion, 31,000 enumerators were employed for the purpose of numbering the people. From a return made to Parliament by the Registrar-General in 1851, we learn that all the local expenses were paid out of the poor-rates in 1841; in 1851 the whole of the expenses were voted by Parliament. In 1841, the cost in England of taking the census of that year, exclusive of postage and printing, was at the rate of £5 9*s.* for every thousand of the population; taking the population of England in the above year at sixteen millions thirty-five thousand and over, this would come to about £87,388. In 1851, when the inquiry was greatly extended, the cost was £5 4*s.* for each thousand; the population then was eighteen millions and rather more than fifty-four thousand; the expense would, exclusive of Scotland and Ireland, be about £93,880.

Photo-Zincography.

From the Lond. Engineer, No. 284.

Colonel Sir Henry James, R. E., Director of the Ordnance Survey, has published the result of various experiments which he has made in photo-zincography, or the art of copying ancient manuscripts, or any outline engravings. Colonel James states that he has been assisted in his labors by Captain A. deC. Scott, R. E. The art is certainly a most useful and valuable one, for, by means of it, rare and important

documents or books may be copied and multiplied to any extent. Thus, a copy has been taken of that part of "Domesday Book" which relates to Cornwall, and the public are likely to reap the benefit of the invention, as a fac-simile of the most expensive books, manuscripts, or engravings, may be obtained at a very cheap rate. We observe, too, that Mr. Erle proposes to republish an early Saxon manuscript by the same means. Half a century ago or so, it was thought that Bewick's engravings could never be surpassed, although we need hardly say that the illustrated publications of the present day evince an almost magical improvement in the art. However, photo-zincography will enable the public to judge of Bewick's engravings, as a pamphlet has been published by Colonel James, containing a photo-zincographic copy of Bewick's "golden eagle," with the view not only of showing the style in which "Bewick's British Birds" were engraved, but also to enable a judgment to be formed of the perfection to which the photo-zincographic process has been brought. The pamphlet to which we allude gives the following description of photo-zincography:—By the term "photo-zincography" is meant, as the name implies, the art of producing a photographic fac-simile of any subject—such as a manuscript, a map, or line engraving, and transferring the photograph to zinc, thereby obtaining the power of multiplying copies in the same manner as is done from a drawing on a lithographic stone or on a zinc plate. The first part of the process concerns the production of a negative photograph on glass of the document of exactly the same size as the original. This is obtained by the ordinary wet collodion process, and too great care cannot be taken to obtain one as perfect as possible, as every defect will be transmitted through each step of the process till it affects the final result. As affecting success at this stage, the lens used should be as perfect as possible, and fully capable of projecting an image of the size required without sensible distortion. Lenses are used at the Ordnance Survey-office of various diameters, depending on the size of the document to be copied—the largest being 8 ins. in diameter, 41 ins. in principal focal length, and capable of producing negatives free from sensible distortion 16 ins. square, a stop 1 in. in diameter being placed 8 ins. in front of it. The distance from the lens to the ground-glass of the camera when adjusted so as to copy a subject in the same size, is 7 ft. 3 ins., and from the lens to the subject of course the same. The readiest means of adjusting the camera and lens in their proper position relatively to the object and to each other when it is required to produce a negative the same size, is to ascertain by actual measurement with a proper scale a lineal dimension of the subject (as its width or length), and so to regulate the distance of the lens from it, that when the image is focussed on the ground-glass it shall equal, in its corresponding dimension, that already read on the scale. This can easily be done by a system of repeated trial and correction of error. When the lens and camera are in adjustment, the glass plate is covered with the sensitive coating—exposed, developed, and fixed in the ordinary way; when fixed, it is immersed in a saturated solution of chloride of mercury (corrosive

sublimate). When well whitened by the action of the salt, it is removed, washed with water, and then with a solution of hydro-sulphate of ammonia, consisting of ten parts of water to one of hydro-sulphate of ammonia of commerce. In this manner the ground of the negative is rendered extremely dense, without affecting the clearness of the detail. When dried and varnished it is ready for use. We now come to the preparations of the sensitive paper. The quality of the paper used is a point of much importance. Various samples have been tried, but that which has been found best suited for the purpose is a semi-transparent kind, with a smooth surface, known by the name of engravers' tracing-paper. The next process is the coating of the whole surface of the print with an even and thin layer of a greasy ink, which is composed of the following ingredients:—Middle linseed-oil varnish, $4\frac{1}{2}$ oz.; wax, 4 oz.; tallow, $\frac{1}{2}$ oz.; Venice turpentine, $\frac{1}{2}$ oz.; gum mastic, $\frac{1}{4}$ oz.; lamp black, $3\frac{1}{2}$ oz. A portion of the above is dissolved in oil of turpentine, so as to make a solution of the consistency of thin cream, which is easily applied to the surface of the print with a brush. As soon as the lines are quite clear, the print is placed in a flat dish, and washed, first with warm, and finally with cold water. When dry, it is ready for transferring to zinc or stone. There are two methods of transferring to zinc, varying according to the quantity of ink on the photograph. If a very small quantity has been applied on account of the closeness of the subject, the print is transferred by the "anastatic" process.

For the Journal of the Franklin Institute.

Particulars of the Steamer Mississippi.

Hull built by Wm. H. Webb. Machinery by Morgan Iron Works, New York. Owners, New York and Savannah Steamship Co. Intended service, New York to Savannah, Georgia.

Hull.—Length on deck, 250 ft. Breadth of beam (molded), 38 ft. Depth of hold, 14 ft. 8 ins. Do., to spar deck, 22 ft. 6 ins. Frames—molded, 15 ins., sided, 16 ins.; apart at centres, 32 ins.; strapped with diagonal and double laid braces, $4\frac{1}{2} \times \frac{3}{4}$ in. Depth of keel, 9 ins. Two bulkheads. Draft of water, fore and aft, 13 ft. 6 ins. Tonnage, 2070. Area of immersed section at load draft of 13 ft. 5 ins., 468 sq. ft. Displacement at load line, 2525 tons. Masts, two.

Engines.—Vertical beam. Diameter of cylinder, 80 ins. Length of stroke, 11 ft. Cut-off, one-half.

Boilers.—Two—Return flue. Length of boilers, 30 ft. Breadth do., 13 ft. Height do., exclusive of steam chimney, 13 ft. Number of furnaces, five in each. Breadth do., 3 ft. 2 ins. Length of grate bars, 9 ft. Number of flues, above, 7 of $13\frac{3}{4}$ ins. and 7 of $14\frac{3}{4}$ ins.; below, 15 of 15 ins. Length do., above, 22 ft. 6 ins.; below, 15 ft. $\frac{1}{2}$-in. Grate surface, 279 sq. ft. Heating surface, 6013 sq. ft. Diameter of smoke pipe, 6 ft. 6 ins. Height do., 36 ft.

Paddle Wheels.—Diameter overblades, 34 ft. Length of blades, 9 ft. 6 ins. Depth do., 24 ins. Number do., 28.

Date of trial, May, 1861. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Caloric Primera.

Hull built by S. Sneden & Co. Machinery by C. H. Delamater, New York. Owners, Pesant, Bros. & Co.

Hull.—Length on deck, 144 ft. Do. between perpendiculars, 135 ft. Breadth of beam (molded), 22 ft. Do., over guards, 34 ft. Depth of hold to spar deck, 9 ft. Length of engine room, 8 ft. Frame—shape, L, depth, 3 ins.; width of web, $\frac{3}{8}$-ins.; width of flanch, 3 ins.; thickness of plates, $\frac{3}{8}$ths to No. 2. Cross Floors—description, T, 9 ins. high, 5-16ths thick; every other frame, angle iron at top, 3-5 × 3-5 × 7-16ths. Rivets, $\frac{5}{8}$ths, single riveted. One independent caloric, fire and bilge pump. Two bulkheads. Stringer plates, fore and aft, 15 ins. wide by 5-16ths thick. Draft of water fore and aft, 6 ft. 3 ins. Tonnage, 284 tons. Area of immersed section at load draft of 6 ft. 3 ins., 132 sq. ft. Masts, two.—Rig, schooner.

Engines.—Double-acting, condensed pressure, caloric. Diameter of cylinder, 40 ins. Length of stroke, 2 ft. Weight of engines and propeller, 70,000 lbs. Number of furnaces, two.

Propeller.—Diameter of screw, 8 ft. Pitch do., 16 ft. Length of blades, 1 ft. 9 ins. Number do., four.

Date of trial, January, 1861. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Steamer North Carolina.

Machinery built by Novelty Iron Works, New York. Owners, H. B. Cromwell & Co. Intended service, New York to North Carolina.

Hull.—Length on deck, 172 ft. Do. load line, 166 ft. Breadth of beam, molded, 29 ft. Depth of hold to spar deck, 13 ft. Frames—sketch of shape, L; depth, 4 ins.; width of web, 3 ins.; width of flanches, 3 ins.; 10 strakes of plates from keel to gunwale, $\frac{1}{2}$ in. thick. Cross floors—description, ⊥, 14 ins. deep, angle iron, 3 × 4 ins. Diameter of rivets, $\frac{3}{4}$ in.; single riveted. One independent steam, fire, and bilge pump. 4 bulkheads. Length of engine room, 16 ft. 9 ins. Draft of water, forward, 9 ft.; aft, 10 ft. Tonnage, 613 tons. Area of immersed section at load draft of 11 ft. Masts, two. Rig, topsail schooner.

Engines.—Vertical direct. Diameter of cylinder, 42 ins. Length of stroke, 3 ft. 6 ins. Maximum pressure of steam, 30 lbs. Cut off, one-third. Maximum revolutions at above pressure, 60.

Boiler.—One.—Return tubular. Length of boiler, 15 ft. 3 ins. Breadth do., 12 ft. 4 inches. Height do., exclusive of steam chimney, 15 ft. 6 ins. Number of furnaces, three. Breadth do., 3 ft. 5 ins. Length of grate bars, 7 ft. 6 ins. Number of tubes, above, 168. Internal diameter do., $3\frac{1}{2}$ ins. Length do., 12 ft. Diameter of smoke pipe, 30 ft. Height do., 22 ft. Consumption of fuel per hour, 844 lbs.

Propeller.—Diameter of screw, 12 ft. Pitch do., 18 ft. Number of blades, 4.

Date of trial, January, 1861. C. H. H.

New Theory of Cementation. By Mons. H. Caron.

From the London Chemical News, No. 81.

The question which I am about to treat is so complex, that I must request the Academy to allow me to establish clearly the facts on which I found my views before I develop them freely.

In a paper which made some sensation, Mr. Saunderson, an ingenious English manufacturer, concludes,* from his experience, that pure and isolated charcoal, oxide of carbon, ammonia, and bicarburetted hydrogen are unsuited for the manufacture of steel; but he shows that iron can be converted into steel by the simultaneous action of ammonia and olefiant gas. After showing that the well known cementation agents, cyanides and ferrocyanides, act only by their metalloid principle, he says:—"1. The transformation of iron into steel only takes place under the combined influence of carbon and nitrogen. 2. If, in analyses of steel, no mention of nitrogen has hitherto been made, the cause of the omission is that the analyses were either ill-done, or that they were made under the influence of a preconceived idea."

May I be permitted to say that Mr. Saunderson has not done justice to his predecessors, Berzelius, Shaffhaütl, Marchand, &c. As a proof, I transcribe an exceedingly judicious note by M. Nickles, Mr. Saunderson's translator:—

"This assertion is not quite correct. There exists a series of analyses of forge iron, cast iron, and steel, attesting the presence of nitrogen in these metals. It is true they do not all contain it, and the greatest quantity that has been found in them is 0·0002 (*Annuaire de Chimie*, 1851, p. 107). These analyses are so much the more reliable since their author, the late M. Marchand, of Halle, experimented from a point of view entirely foreign to the theory of cementation. After it had been established that the titanium of blast furnaces is not a simple body, but a mixture of cyanide and nitride of titanium, M. Marchand surmised the case might be the same with cast iron and steel. Nothing would have pleased him better than to find nitrogen in these carburets, and no one can say that the negative results were obtained under the influence of a preconceived idea. If, then, steel can be considered as free from nitrogen, it is nothing to the purpose that this gaseous metalloid plays no part in the transformation."

Guided by these trials, which had revealed to me the real part nitrogen plays in cementation, I established, in October, 1860, that one of the most powerful and quickest steeling agents is cyanide of ammonium, a gaseous matter, which, by penetrating to the centre of the iron bars, speedily transforms them into steel of great perfection. And it is remarkable that in every instance of Mr. Saunderson's cementing with hydrocarburetted and ammoniacal gases he unwittingly produced cyanide of ammonium. The same observation applies to M. Fremy's experiment, who also brought into contact ammonia and carburetted hydrogen, successively, it is true, but under such circumstances that

* *Journal de Pharmacie et de Chimie*, 1859, vol. xxxvi, p. 301.

at the moment of reaction the two elements were again found together, and, combining, formed cyanide of ammonium.

It remains for me to prove definitely that whenever iron is converted it is always put into contact with gaseous cyanide of ammonium or with volatile cyanides. This is not a difficult task, since Mr. Saunderson has shown that pure charcoal will not convert, and, according to my own experiments, it is the presence of nitrogen concurrently with the alkali of ashes, and, consequently, the formation of cyanide of potassium, which determines the acieration in the cementation cases.

What, then, is the part these cyanides play? If pure or almost pure charcoal is given to iron,—for example, that of the carburetted hydrogen,—as Mr. Saunderson, M. Fremy, and myself have done, and the operation is conducted at the high temperature generally employed, the metal becomes too quickly saturated with the carbon, and cast iron only is the result. But if the metal be placed in contact with a carburetted matter, the elements of which are combined in an affinity so close that the iron can only overcome it by prolonged contact, the acieration produced on the surface of the bars will not exceed the desirable limit before the centre of the iron is cemented. On reflecting over this matter, it will be seen that the only undecomposable and volatile combinations of carbon are the alkaline cyanides. Then, cyanides only are the cementing agents, at least, with the temperatures used in manufacture. This restriction is important, as will presently be established.

But a too prolonged contact or too high a temperature will soon modify the effects produced. Thus, cyanide of ammonium, instead of cementing, can transform iron into cast iron,—a fact I have several times verified. It is not so easy to produce this result with cyanide of potassium, because it is less volatile and more difficult to decompose, from which it may be concluded that the most effective agent in acieration should be the least volatile cyanide,—that is to say, cyanide of barium,* a compound which I have pointed out in another paper. I shall explain more precisely in regard to this substance in another communication on a new cementation process which has been for some months put in practice in a large manufactory in the environs of Paris, by order and at the expense of the Emperor.

All this will become still more clear if it is made apparent that other substances besides cyanides, containing carbon without nitrogen, can convert iron into steel, provided the temperature is not high enough to decompose them, and that their action is not too prolonged. Pure, light carburetted hydrogen gas passed at red-white heat on iron produces not so speedy, but quite as perfect a cementation as cyanides. It is the same with lighting gas,† which contains a considerable proportion of light carburetted hydrogen gas; and if M. Fremy has been unable to convert iron into steel by means of this agent, it is because he operated at too high a temperature, and protracted too long the con-

* Cyanide of barium is easily produced by simply mixing charcoal dust and natural carbonate of baryta. The nitrogen is furnished either by the charcoal itself or by the air which penetrates the sides of the cementation cases.

† Purified by phosphoric acid and solid potassa.

tact by the reagents. Besides, in Berzelius' first edition (vol. iii, p. 279, 1831), there will be found some details on the fabrication of lighting gas, as shown in England by Macintosh. Nevertheless, I agree perfectly with Mr. Saunderson respecting olefiant gas. I have not succeeded in cementing with this gas, though I have operated at the lowest possible temperature, it being too readily decomposed by heat. The tube in which the operation was conducted was found filled with charcoal, and the iron, in spite of tempering, remained soft and malleable.

Strictly speaking, cyanogen is also capable of cementating, but not so well as light carburetted hydrogen gas. These experiments show that to convert iron into steel it is requisite that the cementation agent should be able to carry the charcoal in combination into the pores of the iron when this metal appropriates it in the nascent state. Under no other conditions can cementation be produced.*

After what I have said, it is useless for me to refer to the existence of nitrogen in steels. My theory is perfectly independent. The quotation from M. Nickles' translation, and the cementations so many, including myself, have effected, without the presence of nitrogen, ought, I think, to decide this point. Let it be remembered also that Marchand, in his careful and delicate analyses, could find only such quantities of nitrogen as were either inappreciable or insignificant; that M. Shaffhaütl, the great partisan of the presence of nitrogen in steels, has been obliged to recognise the exactness of Marchand's observations, the same conclusion will naturally be formed as that of this celebrated German chemist,†—"If there is any nitrogen it must necessarily belong to the substances mingled with the iron,—substances which no more form an integral part of the metal than does the scoria found with it."—*Comptes-Rendus.*

A Charter to Dig for Coal.—Newcastle-upon-Tyne, England.

From the Lond. Engineer, No. 272.

The year 1259 is memorable in the annals of coal mining. Hitherto the mineral had not been recognised by authority or in any public document; but in that year King Henry III. granted a charter to the freemen of Newcastle-upon-Tyne for liberty to dig coals. Under the term "sea-coal" a considerable export trade was established with London, and it speedily became an article of consumption amongst the various manufacturers of the metropolis. But its popularity was short-lived. An impression became general that the smoke arising therefrom contaminated the atmosphere, and was injurious to the public health. Years of experience has proved the fallacy of the imputation; but in

*On this subject I will remark, that it is impossible to suppose that nitride of iron can be formed at any moment during cementation in manufacturing operations. M. Despretz's nitride of iron has never been produced by any other means than by ammonia, which does not exist in cementation cases; and, even if it did, it would be decomposed by the temperature at which the operation is performed. As to nitrogen, it is well known that it does not combine directly with iron. The existence of a nitrate of iron before the formation of steel is, then, inadmissible; but atmospheric nitrogen, in contact with charcoal and potash of the ashes, yields cyanide of potassium, which is the reason why the presence of this agent in the atmosphere of the cases is absolutely necessary.

† *Journal fur practische Chimie*, v. Erdmann und Marchand.

1306 the outcry became so general, that the Lords and Commons in Parliament assembled, presented a petition to King Edward I., who issued a proclamation forbidding the use of the offending fuel, and authorizing the destruction of the furnaces and kilns of all who should persist in using it. This was the year before the monarch's death, and the year which saw the overthrow of his life-long attempts upon the throne of Scotland, through the intrepidity of Robert the Bruce. But the proclamation against coal was as abortive as the endeavor to conquer the patriotism of the Scots. Prejudice gradually gave way as the value of the fossil fuel became better known, and from that time downwards its use became more extended; and it is very probable that throughout the 14th and 15th centuries, coal was extracted near the outcrop of the beds over most, if not all, of the coal-fields of Britain and Ireland. Historical records are still extant, from which we learn that collieries were opened during the 14th century in various parts of Yorkshire, Durham, and Northumberland.—*Hull's Coalfields of Great Britain.*

On the Detection of Bisulphide of Carbon in Coal Gas. By Dr. E. Herzog.

From the London Chemical News, No. 78.

A solution is prepared by saturating absolute alcohol with ammonia gas. Then a concentrated aqueous solution of acetate of lead is made, and, to insure saturation, a small portion of the solid salt is left in contact. Both these fluids must be preserved in well-stoppered bottles.

The gas to be tested may be conveniently delivered from a length of vulcanized india-rubber tubing, to the end of which is adapted a narrow glass tube, about five or six inches long. Five drops of the sugar of lead solution are then mixed in a test-tube, with about sixty or seventy drops of the alcoholic ammonia. No precipitate will be formed providing the latter solution has not been allowed to absorb any carbonic acid.

The glass tube delivering the supply of coal gas is now immersed in the mixed solution to a depth just sufficient to allow the gas to be forced out by the existing pressure, and to escape in small bubbles. In the event of bisulphide of carbon being present, the liquid becomes gradually colored, and soon afterwards a yellowish-red precipitate is formed, which, by longer action, assumes a brownish color. If carbonic acid existed originally in the gas, then a white precipitate is thrown down, which imparts to the yellow-red a somewhat lighter color.

As a confirmatory experiment, the gas may be first passed through the alcohol ammonia fluid alone, and the lead solution subsequently added, when an orange-colored precipitate, appearing either immediately or very shortly afterwards, will be formed if bisulphide of carbon is present. In order to meet the objection that sulphuretted hydrogen may perhaps have occasioned this reaction, let some of the gas be first passed through a small quantity of the simple lead solution.

The smallest trace of sulphuretted hydrogen causes a blackening of the liquid, whereas bisulphide of carbon does not alter it in the slightest degree.

It should be mentioned that if the yellow-red precipitate be allowed to remain under the fluid, it gradually changes color, and becomes white after the lapse of about twenty-four hours. If, however, the precipitate be filtered immediately, slightly washed, and dried, it becomes a dark brown.

With regard to the explanation of the chemical reactions which occur in this process, the interesting observations made by MM. Zeise and Debus may be quoted as proving that, by the action of sulphide of carbon on ammonia, according to the concentration and temperature of the fluids and the proportion borne by the ammonia to the sulphide, so will the relative amounts of the products of decomposition vary. In concentrated solutions, and when the ammonia is in excess, sulphocarbonate of ammonium and sulphocyanide of ammonium are formed; in dilute fluids and when sulphide of carbon is in excess, xanthonate of ammonia. Therefore, by this experiment one or other product will preponderate according to circumstances, dependent upon the larger or smaller quantity of sulphide of carbon contained in the gas. In any case, compounds of lead are formed corresponding to the ammonia compounds, which possess at first an orange-red and afterwards a golden-yellow color.

Notwithstanding the complicated nature of the chemical reactions involved in the testing of gas by this process, the author recommends its adoption on account of the practical simplicity which, in his hands, attended the working of a great number of comparative experiments. —*Chemischen Centralblatt.*

New Process for Tinning Iron.

From the London Engineer, No. 282.

The chief object we have in view in coating iron with tin is to protect it from oxidation, since victuals cooked in untinned iron vessels, far from acquiring any poisonous quality, as they would in copper, would, on the contrary, become more invigorating in proportion to the iron they might absorb; only their taste would be impaired, and the vessel itself soon become useless. On the other hand, the tin-coating is not very durable, and the process of tinning has, therefore, to be often repeated. To obviate this inconvenience, MM. Vivien and Lefebvre have imagined a process for covering iron vessels with a film of nickel before applying the tin. They accordingly begin by scouring the vessels in a mixture of 320 grammes of sulphuric acid and 7 litres of water; this is done in a wooden cylinder which is made to turn round for about ten minutes; after which the following substances are added to this bath:—60 grammes of white kitchen-salt, 30 grammes of corrosive sublimate, and 2 grammes of pure sulphate of nickel, and the rotary motion is then continued for about an hour longer. At the end of this time, the vessels are found to have received a fine, uninterrupted, and very adherent coating of nickel,

which effectually protects the iron from oxidation. They are then put into cold water, and left there while the following second bath is being prepared, viz:—River water, 50 litres; cream of tartar in powder, 75 decagrammes; tin in plates, 3 kilogrammes. The whole is made to boil for the space of three hours, after which the iron vessels are put in, and the ebullition is continued for two hours more; by which means the vessels receive a coating of tin deposited on the previous one of nickel. They are then dipped into clean water and rubbed with bran and saw-dust to fit them for use.

The Pantelegraph.

From the Lond. Mechanics' Magazine, June, 1861.

M. Caselli has succeeded by means of his pantelegraph in conveying, between Paris and Amiens, portraits of the Emperor Napoleon, the Empress Eugenie, the Prince Imperial, also a plan of the Battle of Moscow, autographs in French, German, Italian, &c. The Morse signals are reproduced perfectly, by means of this invention, at the rate of fifty or sixty words a minute. Two of these pantelegraphs will soon be at work between Paris and Marseilles. M. Caselli proposes to make experiments on a larger scale by establishing pantelegraphs at London, Paris, Marseilles, Florence, and Naples. By means of this single continuous line, and with only four relays, he proposes to convey between Naples and the other stations named, any document or writing of any kind. M. Caselli has already succeeded in establishing, to less than the one-thousandth of a second, the synchronism of two pendulums, one oscillating at Paris, the other at Marseilles, and these synchronisms are independent of the variations in the current of the electric telegraph which joins the two pendulums.

Decimal Coinage in Denmark.

From the Lond. Mechanics' Mag., June, 1861.

In the kingdom of Denmark a decimal system of coinage has just been adopted. It comprises four denominations of silver, and one of bronze coins. These are named respectively twenty, ten, five, three, and one cent pieces. The largest coin of the series, which corresponds closely in value with the franc of the French Empire, has for its obverse the well-engraved and massive-looking head of the king in profile, and surrounded by the legend "Frederick III., Konge Af Danmark," with the date. The reverse represents a ship in full sail over a rippled sea, and bears the inscription, which we leave Danish scholars to translate—"Dansk Vestindisk Mout," with the value of the coin "20 cents," underneath. The ship, no doubt, is emblematical of the commerce of the country, and the superiority of its inhabitants as navigators. The next coin in point of value, although decorated with the head of the monarch for its obverse, and having the same legends, has a reverse design of quite a different character; namely, a tall shrub or plant, in flower, which is, of course, indige-

nous to Denmark. It presents a rather singular appearance. As, however, agriculture is largely pursued by the people, it is not an inappropriate device. The five cent piece is a reduced fac-simile of the first named, whilst on the three cent coin neither ship nor shrub appears, but in their place a conspicuous figure 3 is seen, with the word cents below it. The one cent bronze bears no family likeness to its silver relatives. In place of the royal head, it has for its obverse the royal arms, which consists of three lions, each surmounted by three hearts, on a shield, and with a crown placed above the whole, the inscription being "Frederick VII., Konge Af Danmark." The reverse exhibits simply a wreath of oak leaves, encircling the value of the coin, "1 cent," and has the inscription "Dansk Vestindisk," immediately within the ingrained edge. The coins are all well proportioned as regards thickness and diameter, and well engraved; and while the edges of the silver pieces are milled or grained, in a manner resembling our own gold and silver moneys, those of the bronze coins are plain.

We cannot but congratulate our Danish friends on having obtained a system of decimal coinage which, while it will facilitate marvellously the transactions of trade, will economize to no inconsiderable extent the time of the schoolmaster and the book-keeper. When will Great Britain follow suit?

AMERICAN PATENTS.

AMERICAN PATENTS ISSUED FROM JUNE 1, TO JUNE 30, 1861.

Air Chambers, .	Robert Creuzbaur, .	Travis co.,	Texas,	18
Apple Parer, .	S. S. Hersey, .	Farmington,	Me.	18
Arastra, .	Woodworth & Wethered,	Murphys,	Cal.	11
Axle Collars, .	E. S. Scripture, .	City of	N. Y.	4
Bedstead Drapery Fastener,	R. B. Pullan, .	Cincinnati,	Ohio,	18
———,—Trunk convertible to	W. B. Strong, .	City of	N. Y.	11
Beehives, .	R. Bullard, .	Litchfield,	Mich.	4
——— .	Oliver Reynolds,	Webster,	N. Y.	4
Bell-ringing Apparatus, .	Rhodolphus Kinsley, .	Springfield,	Mass.	11
Bit Stock, .	John F. Cory, .	City of	N. Y.	25
Boiling Apparatus, .	John McCormick, .	Madison,	Ind.	25
Bolts,—Heading .	James Weathers,	Greensburg,	"	11
Boot Heels, .	George A. Mitchell, .	Turner,	Me.	25
—— Jack, .	W. H. Towers, .	City of	N. Y.	4
Boots and Shoes, .	J. C. Plumer, .	Portland,	Me.	4
——— .	Christopher Meyer,	N. Brunswick,	N. J.	18
Boot & Shoe Soles,—Skiving	Wm. F. Trowbridge,	Feltonville,	Mass.	25
Boring and Mortising,	S. W. Bidwell, .	Hartford,	Conn.	11
——— Machine, .	S. L. Fitts, .	Ashburnham,	Mass.	11
Bottles,—Inserting Stoppers in	Amasa Stone, .	Philadelphia,	Penna.	18
Bottle Stoppers, .	J. A. Preston, .	Boston,	Mass.	25
Brakes,—Car .	G. W. Bridgman,	Somerville,	"	11
——— .	W. R. and H. E. Kay,	Westerly,	R. I.	25
——— for Vehicles,	J. A. Whitney, .	Maryland,	N. Y.	25
Bridges,—Braces of Iron .	A. D. Briggs, .	Springfield,	Mass.	18
———,—Trusses of	J. H. Junkins, .	U. Sandusky,	Ohio,	4
Brush,—Flexible Back .	J. J. Adams, .	City of	N. Y.	18

Brush,—Galvanic Metal Friction	L. A. Hoffman, .	Prussia,		25
Buggy Tops, .	L. H. Gano, .	Ripon,	Wis.	18
————,—Frames of	J. H. Havens, .	Troy,	Ohio,	4
Burglar Alarm & Animal Trap,	George Smith, .	City of	N. Y.	11
Canal Boats,—Stanchion for	C. Van Name, .	Binghampton,	N. Y.	11
Carpet Cleaner, .	George & Carter, .	Nashua,	N. H.	4
Car Spring, .	G. L. Turner, .	City of	N. Y.	18
Carriage Bodies, .	W. C. and J. Dunn, .	"	"	11
——— Steps, .	H. T. Betts, .	Springfield,	Mass.	4
Chair,—Adjustable .	Amos Chase, .	North Weare,	N. H.	11
Chairs,—Cane Seat for	J. B. Sawyer, .	Templeton,	Mass.	11
Camp Chest, .	George Parr, .	Buffalo,	N. Y.	25
Churn, .	C. T. Anderson,	Hyattstown,	Md.	18
Cloth,—Making Felt .	G. G. Bishop, .	Norwalk,	Conn.	25
Clothes Frame, .	M. J. Knox, .	Knox Corners,	N. Y.	18
——— Wringer, .	G. B. Griffin, .	Madison,	Wis.	4
———— .	W. B. Rhoades,	South Dedham,	Mass.	25
Clover Seed,—Hull'g & Clean'g	F. E. Cook, .	Guilford,	Ohio,	4
————————	Jacob Kuhn, .	Centerville,	Penna.	25
Coolers and Condensers,	Wm. A. Lightall, .	City of	N. Y.	11
Coupling,—Belt .	Samuel Metzler,	Naperville,	Ill.	25
————,—Car .	Abraham Stroh, .	Port Jervis,	N. Y.	11
———— .	A. H. Trego, .	Lambertville,	N. J.	11
Cork Machines, .	Isaac Goodspeed, .	Norwich,	Conn.	4
Corn Broom, .	C. L. W Baker,	Hartford,	"	11
Cotton Seed,—Detach. Fibres	L. P. Jenks, .	Boston,	Mass.	25
Crane,—Portable .	L. A. Beardsley,	S. Edmeston,	N. Y.	25
Cranks,—Overcom. Dead Point	John Griffin, .	Louisville,	Ky.	11
Cultivators, .	Cain & Stelfox,	Austin,	Texas,	4
———— .	R. F. Joynes, .	Bristol,	R. I.	4
———— .	John Keezer, .	Chillicothe,	Ohio,	18
———— .	Joseph & St. Clair Gum,	Marseilles,	Ill.	18
Curry Combs, .	H. L. Baldwin, .	Branford,	Conn.	11
Cut Nails,—Annealing .	James McCarty, .	Reading,	Penna.	11
Daguerreotype Cases,	Ralph Hill, .	City of	N. Y.	18
Dish Covers,—Wire Cloth	L. H. Allen, .	Amherst,	Mass.	4
Drawing Instrument,	John P. Jamison,	City of	N. Y.	18
Electro-magnet, .	A. G. Holcomb, .	City of	N. Y.	4
Evaporating Liquids,—Apparat.	John Trageser, .	"	"	11
Excavating Machine, .	W. F. Wickersham, .	St. Louis,	Mo.	25
Excavators, .	Jesse Bartoo, .	East Aurora,	N. Y.	4
Fire Arms,—Breech-loading	Herman Schroder, .	City of	N. Y.	25
Fruit-drying Apparatus,	Eli Duncan, .	West Hilton,	Ohio,	18
Furnaces of Locoms.—Blowers	F. B. Blanchard, .	City of	N. Y.	25
Gauge,—Pressure .	Finnegan & Schulte,	City of	N. Y.	11
Galvanic Soles, .	Samuel Nowlan, .	"	"	18
Games of Chance,—Select. Balls	Mortimer Nelson,	"	"	18
Gas by Electricity,—Lighting	Robert Cornelius, .	Philadelphia,	Penna.	4
—— Regulators, .	G. H. Smith, .	Rochester,	N. Y.	25
Grain Drills, .	H. A. and L. B. Myers,	Elmore,	Ohio,	25
——— Winnowers,	H. H. Beach, .	Philadelphia,	Penna.	11
Griddles,—Moulding Stove	M. C. Burleigh, .	Somersworth,	N. H.	4
Harrows, .	Moses Bucklin, .	Grafton,	N. H.	4
———— .	J. T. Foster, .	Jersey City,	N. J.	18
———— .	T. C. Hooker, .	Kendall,	N. Y.	18
————,—Seeding .	Edward Badlam, .	Ogdensburgh,	"	18
Harvesters, .	Robert Brown, .	Frederick,	Md.	18
———— .	G. W. Richardson, .	Grayville,	Ill.	25

Harvesters,—Rakes for	W. S. Wilmot, .	City of	N. Y.	4
Harvesting Machines, .	Franklin Clark, .	Charlotte,	"	18
Hat Bodies,—Felting	Russell Smith, .	Danbury,	Conn.	4
Hats,—Circ. Looms for Weav'g	Louis Bonard, .	City of	N. Y.	4
Heating Apparatus,	Porter Mitchell, .	Greenfield,	Mass.	25
—————,—Steam	Wm. C. Baker, .	City of	N. Y.	4
Hemming Guides .	G. L. Jencks, .	Providence,	R. I.	11
Hemp Brakes, .	J. H Phillips, .	Waverly,	Mo.	11
Hinges, .	C. M Lane, .	Cincinnati,	Ohio,	4
Hominy Machines, .	David Haines, .	Union Bridge,	Md.	11
Horse-hitching Posts,	Chas. Bush, .	Newburgh,	N. Y.	18
Horse Shoes,—Making .	C. H. Perkins, .	Providence,	R. I.	25
Hydraulic Jack, .	R. Blackwood, .	Philadelphia,	Penna.	25
Inkstands,—Barometer .	T. S. Hudson, .	E. Cambridge,	Mass.	4
Iron and Steel,—Malleable Cast	A K. Eaton, .	City of	N. Y.	25
Journal Box, .	Joel Webster, .	Brooklyn,	N. Y.	18
Lamps, .	E. F. Slocum, .	Chicago,	Ill.	11
Lard,—Refining .	H. S. Lewis, .	"	"	25
Leather,—Dressing	Charles Korn, .	Meriden,	"	25
———,—Tanning .	H. McKenzie, .	Talladega,	Ala.	11
——— for Soling,—Preparing	Davoust Kern, .	York,	Penna.	25
Lock. .	John Adt, .	Waterbury,	Conn.	25
Locks and Knob Latches,	A. M. Hill, .	Branford,	Conn.	11
——————— .	W. S. Kirkham, .	"	"	11
Looms. .	Caspar Zwicki, .	Pittsburgh,	Penna.	4
———,—Picker Motion for	John Robinson, .	Andover,	Mass.	18
——— or Weaving Hair Cloth,	Isaac Linsley, .	Providence,	R. I.	25
Lubricating Compound, .	A. Lebkucher, .	Belleville,	Ill.	25
Medical Powder Papers,—Filling	Mark S. Palmer,	New Bedford,	Mass.	25
Melodeons, .	Wm. F. Sheldon, .	East Mendon,	N. Y.	25
Mercury in Vessels,—Condens.	Van Buren Ryerson,	City of	"	4
Mills,—Grinding .	S. S. Howard. .	Milton,	"	18
———— .	Krause & Strong,	Chicago,	Ill.	18
Millstones,—Leveling .	Andrew Dray, .	Portland,	Oregon,	18
————,—Feeding Grain to	S. G. Morrison, .	Williamsport,	Penna.	18
————,—Ventilating .	" .	"	"	18
Nail Heads, .	Nichols & Strong,	E. Hampton,	Conn.	11
—— Machine,—Horse-shoe,	S. S. Putnam, .	Dorchester,	Mass.	11
Oils,—Distilling .	Kelley & Tait, .	City of	N. Y.	18
Ox Yokes, .	T. W. Porter, .	Bangor,	Me.	25
Padlock, .	J. J. Hirschbuhl,	Louisville,	Ky.	18
Paint,—Article of .	Isaac Tyson, Jr., .	Baltimore,	Md.	4
Paving and Pulverizing the Soil,	R. J. Gatling, .	Indianapolis,	Ind.	18
Photography, .	J. W. Osborne, .	Melbourne,	Engl'd,	25
Pipe Butts, .	L. S. Bunnell, .	Troy,	N. Y.	4
Pistols,—Toy .	Cutler & Jenkins, .	City of	"	25
Ploughs, .	Zadoc M. Beall,	Russellville,	Ky.	4
——— .	Wm. Lape, .	Troy,	N. Y.	25
——— .	L. M. Stearns, .	Cardiff,	"	4
———,—Hillside .	Augustus Sanborn, .	Glover,	Vt.	18
———,—Steam	C. W. Saladee,	Pine Island,	Texas,	25
Preserve Jars, .	J. M. Whitall, .	Philadelphia,	Penna.	18
Propeller,—Screw	David Bell, .	Buffalo,	N. Y.	25
Pumps, .	Nathan Barrett, .	City of	"	25
——— .	Nathan Miller, .	Finley,	Ohio,	18
——— .	W. W. Robinson, .	Ripon,	Wis.	4
——— .	V. Weitz, .	Cleveland,	Ohio,	18

Railroads,—City .	E. F. Hyde, .	Brooklyn,	N. Y.	11
Railroad Switch, .	O. W. Marshall,	Windsor Locks,	Conn.	18
Railways,—City .	P. Andrew, .	Cincinnati,	Ohio,	25
Ratan Machine, .	N. H. Richardson,	Fitchburg,	Mass.	25
Rope,—Opening .	Richard Mansley, .	Philadelphia,	Penna.	11
—— Walks, .	Horace Maxson,	Hopkinton,	R. I.	4
Rulers, .	George Lane, .	City of	N. Y.	18
Sash-holders, .	H. T. Stanard, .	Wayne,	Mich.	25
Saw Teeth,—Cutting .	J. D. Custer, .	Norristown,	Penna.	25
Saws to Arbors,—Circular	John Andrews, .	Brunswick,	Me.	11
Sawing Machines,—Scroll	L. D. Barrand, .	City of	N. Y.	11
Seed Drills, .	John and Saml. Fahrney,	Washington co.	Md.	18
Seeding Machines, .	Grout & Lawton, .	Oak Grove,	Wis.	4
————	Gilbert Jessup, .	Chapinville,	N. Y.	25
Sewing Machines, .	Wm. M. Fuller, .	Chicago,	Ill.	4
———— .	Edward Howell,	Ashtabula,	Ohio,	11
————,—Threader &c.	J. W. Hardie, .	City of	N. Y.	25
Shingle Machines,	A. H. Clark, .	Fond du Lac,	Wis.	4
————,—Tilt. Device	D. M. Boyd, .	Indianapolis,	Ind.	25
Ships,—Life or Safety	Mathew Gill, .	Battle Creek,	Mich.	25
Shoulder Straps,—Officers'	J. S. Smith, .	City of	N. Y.	18
Sirups,—Decolorizing	H. N. Fryatt, .	Belleville,	N. J.	25
Skates, .	J. A. De Brame, .	City of	N. Y.	4
—— .	D. H. Shirley, .	Boston,	Mass.	25
Skirts,—Hoop .	S. R. Wilmot, .	Brooklyn,	N. Y.	11
Skirt Supporters, .	Sarah A Baldwin,	Waterbury,	Conn.	11
Soda,—Caustic .	Henry Lowe, .	Baltimore,	Md.	11
Spike Machine, .	Samuel Cameron,	Pittsburgh,	Penna.	4
Spoke Shave, .	Martin Colton, .	Sardinia,	N. Y.	25
Spools,—Turning .	J. S. Parker, .	W. Willington,	Conn.	11
Steam Boiler, .	F. B. Blanchard, .	Brooklyn,	N. Y.	25
—— Boilers,—Apparatus for	G. W. Rains, .	Newburgh,	"	11
————,—Damper for	J. R. Robinson, .	Boston,	Mass.	11
————,—Safety Guard	George Mann, Jr.,	Ottawa,	Ill.	18
————,—Tubular Grates	S. C Sturtevant, .	Cleveland,	Ohio,	11
—— Engines, .	E. W. Smith, .	City of	N. Y.	11
————,—Governors for	C. T. Porter, .	"	"	18
————,—Rotary Valve	Jerome Wheelock,	Worcester,	Mass.	18
————,—Slide Valve	A. J. Stevens, .	Aurora,	Ill.	18
————,—Valve Gear	J. R. Robinson, .	Boston,	Mass.	11
—— Heating Apparatus,	Charles Gregg, .	City of	N. Y.	18
Steel,—Converting Iron into	E. R. Weston, .	East Corinth,	Me.	11
Stills,—Securing Bottoms to	J. G. Collins, .	Boston,	Mass.	18
Stoves,—Fire Pot for Coal	Dennis G. Littlefield,	Albany,	N. Y.	25
Teasels,—Trimming .	George M. Rhoades, .	Hamilton,	N. Y.	25
Telegraphic Apparatus,	C. H. Burd, .	Roxbury,	Mass.	11
Tent Fixtures, .	J. H. Landell, .	Newark,	N. J.	4
Thrashing and Separating Grain,	Hiram Aldridge,	Michigan City,	Ind.	11
—— Machines, .	W. P. Penn, .	Belleville,	Ill.	18
Tobacco,—Curing	B. C. Bibb and others,	Baltimore,	Md.	25
—— Cutters, .	H. U. and H. A. Morse,	Canton,	Mass.	25
Traps,—Animal .	Decatur Pittman,	Fort Madison,	Iowa,	4
Trap,—Steam .	Wiggin & Hoard, .	Providence,	R. I.	4
Trimmings,—Making Tape	J E Earle, .	Brooklyn,	N. Y.	25
Tube and Pail Machine, .	Peck & Gifford, .	Wolcott,	Vt.	25
Valves, .	Leopold Thomas,	Allegheny,	Penna.	25
Ventilating Hay, Grain, &c.,	Abel Post, .	Henrietta,	N. Y.	18
Wall Paper, &c.,—Bronzing	W. G. Mackay, .	City of	N. Y.	25
Washing Machines, .	Horace Boies, .	Hamburgh,	"	25

Washing Machines,	H. M. Collier, .	Binghampton,	N. Y.	4
——— .	D. R. Gamble, .	Newark,	Ohio,	25
———	E. Gore, .	Belvidere,	Ill.	4
Water Elevators, .	A. W. Dewey, .	Boston,	Mass.	25
——— .	Joel Lee, .	Galesburg,	Ill.	25
——— .	F. B. McGregor, .	Commerce,	Mich.	18
——— .	Eli Mosher, .	Flint,	"	18
——— .	George Race, .	Norwich,	N. Y.	25
——— .	M. A. Shepard, .	Bridgeport,	Ill.	25
——— for Cattle	Nathan Miller, .	Finley,	Ohio,	18
———	M. D. Wilder, .	Laporte,	Ind.	25
Window Blinds, .	D. deForest Douglas,	Springfield,	Mass.	11
——— Sash,—Hanging	George Dare, .	Auburn,	N. Y.	4
——— Shades,—Manufact. of	F. A. Perry, .	St. Louis,	Mo.	11
RE-ISSUES.				
Car Spring, .	Richard Vose, .	City of	N. Y.	4
Fire Arms,—Breech-loading	Christian Sharps, .	Philadelphia,	Penna.	18
Grain Separators (2 patents),	J. A. Vaughn, .	Cuyahoga F'ls,	Ohio,	11
Harvesters, .	Wm. N. Whiteley, Jr.,	Springfield,	"	25
Hemp,—Cutting (3 patents),	"	"	"	18
Locks,—Door .	G. D. Baldwin, .	City of	N. Y.	4
Seeding Machines,	Lewis Moore, .	Ypsilante,	Mich.	18
Shirt Bosoms, .	Ira Perego, Jr., .	City of	N. Y.	11
DESIGNS.				
Coffins, .	James McDuff, .	Morrisania,	N. Y.	25
Daguerreotype Cases,—Mat for	H. W. Hayden, .	Waterbury,	Conn.	25
Oil-cloth Pattern, .	James Hutchinson,	Lansingburgh,	N. Y.	25
Trade Mark, .	Levi L. Tower, .	Boston,	Mass.	11
Tumblers, .	C. S. Chaffee, .	E. Cambridge,	"	25

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, August 15, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President, } Present.
Isaac B. Garrigues, Recording Secretary, }

The minutes of the last meeting were read and approved.

Letters were read from Thomas Oldham, Esq., Superintendent of the Geological Survey of India, and of the Geological Museum, Calcutta, India; and from Messrs. Eives & Macey, London, England.

Donations to the Library were presented by the Statistical Society, and the Institute of Actuaries, London; the Royal Irish Academy, Dublin, Ireland; the Society for the Encouragement of Industry in Prussia, Berlin, Prussia; the Governor-General of India, Calcutta, India; the Regents of the University of New York, Albany, New York; and from Jacob S. Miller, Esq., Philip Price, Esq., George M. Conarroe, Esq., and Prof. John C. Cresson, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of July was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (2) were proposed, and the candidates proposed at the last meeting (2) were duly elected.

Mr. Howson called the attention of those present to a new form of Scale-beam, the invention of Mr. A. B. Davis of this city. The improvement consists in the use of a supplementary beam suspended by a clevis beneath the beam as usually constructed, and the article to be weighed being suspended from a clevis attached to the lower beam.

The upper beam is graduated in the usual manner, and is furnished on each side with three knife edge bearings of the usual form, the beam being supported by a stationary clevis, in which the centre bearings rest.

The second graduated beam is situated immediately below the first, and is provided at each end with knife edge bearings situated directly beneath those on each end of the upper beam; the two beams being connected by a clevis suspended on the bearings.

Between the two knife edge bearings on the lower beam is situated another, from which depends a clevis for receiving the object to be weighed. While the bearings at the ends of the beams are an equal distance apart on each beam, the distance between the end bearing and the bearing supported by the stationary clevis on the upper beam, is greater than the distance between the end bearing and that holding the weighing clevis on the lower beam; the two beams being graduated into spaces equal to the difference of the distances of the central bearings from the end ones, so that a weight of 20 lbs. suspended to the central clevis of the lower beam would exactly balance a weight of 1 lb. placed at a notch twenty spaces from the fulcrum on the upper beam.

It would be impossible to suspend the clevis holding the object to be weighed directly to the upper beam so near its fulcrum, as it would interfere with the proper movements and functions of the beam; hence the employment of the supplementary beam, which obviates the necessity of using the usual long beam, and produces a more compact and manageable weighing apparatus.

This will be more apparent when it is borne in mind that the distance between the two centre bearings may be, if necessary, but one-tenth of an inch, in which case a weight of 1 lb. hung to the upper beam at the distance of ten inches from its fulcrum, would balance a weight of 100 lbs. suspended from the centre bearing of the lower beam.

One of the main advantages gained by this improvement is, that the two beams afford an opportunity of weighing the tare on one beam and the actual merchandize on the other. If a cart-load of coals be on the platform of the scale with which the beams are connected, the weight on one beam is adjusted to a point which will balance the weight of the horse and cart, so that when the sliding weight on the lower beam is adjusted to a point which will balance the horse and cart, together with the contents of the latter, the actual weight of the contents may be at once ascertained without any calculation.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

JULY.—The mean temperature of July was 76·1°, which is nearly one degree lower than that of July, 1860, and two degrees below the average temperature of July for eleven years.

The warmest day of the month was the 8th, of which the mean temperature was 87·8°. The highest point indicated by the thermometer was 95° on the same day.

The coldest day was the 14th, of which the mean temperature was 64·2°. The 2d day of the month was but eight-tenths of a degree warmer. The thermometer indicated the lowest temperature (55°) on the morning of the 3d. The range of temperature for the month was 40°.

The greatest daily oscillation or change of temperature in the course of one day, was 26° on the 3d. The least daily oscillation was 9° on the 14th. The average oscillation for the month (19·29°) was but one-tenth of a degree greater than the average for July for eleven years, and half a degree less than for July, 1860.

The greatest daily range of temperature—that is, the greatest mean difference of temperature between two successive days—was 9·3° between the 2d and 3d; the least was eight-tenths of a degree between the 23d and 24th. The average daily range for the month was 3·7°, which was very near the average for eleven years, but was more than one degree less than that for July, 1860.

The atmospheric pressure was greatest (29·961 inches) on the 5th, and least (29·505 inches) on the 20th; but the mean daily pressure was least (29·552) on the 10th of the month. The average pressure for the month (29·781) was less than for any other month of July since 1851, when it was but 29·743 inches.

The greatest mean daily range of pressure for the month was 0·197 of an inch, and occurred between the 20th and 21st; the least was 0·010 of an inch between the 4th and 5th; and the average for the whole month was 0·078 of an inch, which is five-thousandths of an inch less than usual, and more than three-tenths of an inch less than for July of last year.

The force of vapor and dew point were greatest on the 29th and least on the 2d of the month, and both were less than the average for eleven years. The relative humidity was greatest on the 14th, and least on the 3d and 4th of the month. It was a little over one per cent. less than the general average for the month, though greater than usual at 9 P. M.

Rain fell on 14 days of the month, to the aggregate depth of 2·826 inches. This was two inches more than fell in July of last year, but was nearly one inch less than the average amount for the month. The number of rainy days was greater than usual, though but a small quantity of rain fell on each occasion.

Thunder showers occurred on seven days of the month, viz: on the 9th, 10th, 19th, 20th, 27th, 28th, and 31st. During that of the 9th, a house in Walnut street above Fifth was struck by lightning. The fluid knocked down a chimney, tore off a portion of the roof, and then de-

scended to a frame shed, which it broke into small fragments. The telegraph wires running through the city were so much injured that communication by them was interrupted for several hours. No lives were lost.

There was not one day during the whole month entirely clear, or free from clouds, and the sky was completely covered at the hours of observation on three days of the month, the 1st, 14th, and 22d.

The 4th of July.—As an interesting item of information, I give the following record of the mean temperature and general character of the weather, at Philadelphia, on the 4th of July, from 1851 until the present time.

1851. 71·0°. Cloudy, wind N. W.
1852. 74·5. Morning and evening, cloudy; afternoon, clear.
1853. 79·3. Morning, light rain, cloudy.
1854. 86·5. Clear.
1855. 80·7. Cloudy; shower in afternoon; drizzling all the evening.
1856. 78·2. Morning and afternoon, cloudy; evening, clear; a few drops of rain in the afternoon.
1857. 66·3. Cloudy.
1858. 83·5. Morning and afternoon, cloudy; evening, clear.
1859. 63·2. Clear. The coldest day of the month.
1860. 79 0. Morning, cloudy; from 5½ P. M. until 6½ P. M., rain; evening, clear.
1861. 79·3. Clear.

A Comparison of some of the Meteorological Phenomena of July, 1861, *with those of July,* 1860, *and of the same month for eleven years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	July, 1861.	July, 1860.	July, 11 years.
Thermometer.—Highest,	95°	95·5°	100·5°
" Lowest,	55	57·0	53·0
" Daily oscillation,	19·29	19·80	16·19
" Mean daily range,	3·70	5·00	3·77
" Means at 7 A. M.,	72·74	72·50	73·97
" " 2 P. M.,	82·87	83·89	83·84
" " 9 P. M.,	72·69	74·34	76·41
" " for the month,	76·10	76·91	78·07
Barometer.—Highest,	29·961 in.	29·979 in.	30·212 in.
" Lowest,	29·505	29·495	29·443
" Mean daily range,	·078	·112	·092
" Means at 7 A. M.,	29·800	29·811	29·856
" " 2 P. M.,	29·765	29·774	29 825
" " 9 P. M.,	29·780	29·787	29 840
" " for the month,	29·781	29·791	29·840
Force of Vapor.—Means at 7 A. M.,	·578 in.	·539 in.	·614 in.
" " " 2 P. M.,	·540	·505	·611
" " " 9 P. M.,	·579	·559	·639
Relative Humidity.—Means at 7 A. M.,	71 per ct.	66 per ct.	72 per ct.
" " " 2 P. M.,	48	43	53
" " " 9 P. M.,	72	65	70
Rain, amount in inches,	2·826 in.	0·851 in	3·730 in.
No. of days on which rain fell,	14	10	10·7
Prevailing winds—Times in 1000-ths,	s 58°43′w ·368	s70°1′ w ·135	s62° 54′w 147

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

OCTOBER, 1861.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Bridge over the Theiss, and Tubular Foundations. By M. Cezanne, Engineer des Ponts et Chaussées. Translated by J. Bennett.

(Continued from page 154.)

A short notice of a Pneumatic Pile Bridge across the Savannah River.

I am indebted to my friend C. C. Martin for the following sketch of his experience in pneumatic pile-driving. After the completion of the Brooklyn Water Works, during which Mr. Martin was connected with me in the construction of the dams and preparation of the ponds of that work, he took charge of the pneumatic pile bridge across the Savannah River, where he prosecuted the work successfully, until interrupted by the war of the Rebellion.

The Savannah River Bridge is to be on the line of the Charleston and Savannah Railroad, about 16 miles from the latter city; when completed, it will consist of six fixed spans, and a swing bridge, with an aggregate length of 900 feet.

The two abutments and seven piers are to consist of pneumatic piles; the abutments and four piers to be of two piles each; the piers at the end of the swing bridge to consist of four cylinders each, and the pivot pier of five. The cylinders are cast in sections 9 feet in length, and 6 feet outside diameter, with 2 inches thickness of metal;

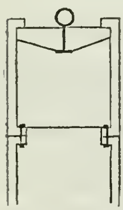
the lower section of each column is cast or turned with a bevel edge,

as shown, in order that it may offer the least possible resistance as it descends; the upper end of this section, and both ends of the others, have a flanch on the inside 3″ wide and 2″ thick, through which are 40 holes 1 inch in diameter, to admit bolts for joining the sections together. The ends of each section were turned in a lathe, so as to be parallel, and thus insure the straightness of the cylinder, though composed of several sections. The cylinders were cast and fitted up by the Trenton Locomotive and Machine Manufacturing Co., of Trenton, N. J., and are certainly monuments of mechanical skill, and do great credit to the manufacturers.

Apparatus.—The apparatus for sinking these piles consists of a large flat boat, upon which is placed a 16 H. P. steam engine, and two double-acting air-pumps; a hoisting apparatus, consisting of a drum driven by the engine, sheer poles, blocks and falls.

The Savannah River at this point has a velocity of about four miles per hour; the tide rises and falls about three feet. The river bottom is composed of clean river sand for a depth of 20 feet, when a strata of coarse clean gravel is found, about 2 feet thick; below this is a stratum of blue material, composed of sand and clay, very compact. The water in the river is always charged with yellow clay, from the interior, so that it is impossible to see beneath the surface; the depth varies from 2 or 3 feet at the shore to 16 feet at the middle.

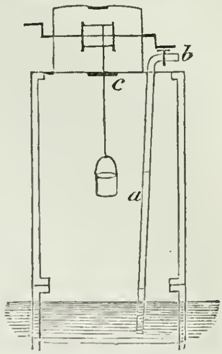
Process of Sinking the Cylinders.—Two sections of cylinder were bolted together, the joint being made air-tight with white lead; both were lifted together and suspended while the "Flat" was being hauled into position by watch tackle running in different directions. When the cylinder was thus brought immediately over the place it was to occupy, it was gradually lowered till the bottom rested on the sand.



These two sections were held in position by guys, while another section was lowered upon them and secured. The sections are hoisted by means of a piece of timber with an eye-bolt, as shown in sketch. The workmen go down in the inside to put in the bolts and secure them, being supported by planks resting on the flanches. A cast iron cap is then secured on the top of the cylinder, and to this is attached a hose connecting with the air-pumps; a large cast iron receiver intervening to receive the water which is pumped out. The pumps being set in motion, the air and a portion of the water in the cylinder is drawn out, and a partial vacuum formed, producing a pressure on the top sufficient to force the cylinder into the sand. In one instance where four sections were bolted together, being in fifteen feet of water, and about four feet in the sand, the cylinder sunk six feet in three minutes on the application of a vacuum. The settlement is generally from one to four feet.

Air-lock.—The next step is to place upon the top of the cylinder an "air-lock," after removing the "vacuum-cap;" this is a section made of boiler iron, arranged with a door in the top and bottom, both

opening downward, large enough to admit a man, and closing air-tight. The air-lock is smaller in diameter than the cylinder, and this allows the insertion of "bull eyes" for admitting light; also a butt and stop-cock. Inside of the air-lock, is a windlass for hoisting material from inside the cylinder. The hose from the air-pumps is now connected with the butt which opens into the inside of the cylinder; the syphon-pipe, *a*, is secured in place, connecting with a stop-cock on the outside of the cylinder on top, at *b*. The bottom door, *c*, is closed, and air is forced into the cylinder by the pumps. The stop-cock is opened, and the water is pressed down by the air above it in the cylinder, and is forced up the syphon-pipe, through the stop-cock, into the open air. As soon as the water is as low as the bottom of the pipe, *a*, men are sent inside to add other sections, and thus lengthen it. The men are admitted as follows: the bottom door being closed, the top one is opened, and men descend into the air-lock, and close the top door; then, by means of a small air-cock in the bottom of the air-lock, the pressure is admitted from below into the air-lock. This closes the top door air-tight, and the pressure in the air-lock becomes equalized with that below, and the bottom door falls by its own weight, and the men descend by means of rope-ladders suspended from the under side of the air-lock bottom. In coming out of the cylinder, the men come into the air-lock and close the bottom door; then, by means of a small air-cock in the side of the air-lock, the pressure is allowed to escape, and the top door falls open.



In allowing the pressure from below to enter the air-lock, great caution is necessary, else exceedingly painful sensations are experienced; different persons are differently affected; nearly all experience a painful sensation in the ears, and some oppression of the lungs, bleeding at the nose, headache, dizziness, &c. As soon as the pipe is lengthened, the stop-cock is again opened, and by a repetition of the process, all the water is forced out of the cylinder, and, by a continuation of the same process, the sand is forced up the syphon-pipe with great force in astonishing quantities; by this means, the sand is all excavated from within the cylinder. A phenomenon scarcely to be expected occurs: on the excavation near the bottom, the air escapes under the bottom of the cylinder, rises through the sand, and escapes in bubbles through the water, in some cases over an area of one hundred feet in diameter; this keeps the water entirely out of the cylinder, and enables the workmen to conduct their operations easily.

Having excavated to the bottom, the men come out, first having removed several lengths of the syphon-pipe, and raised up their ladder, the pressure still continuing. As soon as they are out and all is ready, the stop-cock is opened and the compressed air allowed to escape suddenly; this removes the upward pressure from within, and

the cylinder by its own weight forces itself into the sand, being resisted only by the friction against the sand on the outside, and the material immediately under the lower edge of the cylinder; these are both exceedingly small while the compressed air is escaping, for the water rushes in under the bottom, bringing with it great quantities of sand, which must move with the water down the outside of the cylinder. The cylinder, which sunk six feet by a vacuum, sunk nine feet in about two minutes by allowing the pressure to escape. By a repetition of this process of excavation and "blowing off" pressure, the cylinders were sunk from 25 to 30 feet into the bottom of the river, being from 3 to 7 feet in the hard strata of clay and sand. The cylinders are to be brought up to the grade of the road (about fifteen feet above the surface of the water) by sections cast of the requisite length; they are to be connected together by means of wrought iron ties and braces, and are to have cast iron capitals to receive the chords of the wooden superstructure, which is to be a Howe-truss.

Inclination of Cylinders.—It frequently happens in sinking cylinders that, owing to inequalities in the density in the quality of the material which it penetrates, the cylinder becomes inclined, and it is a very difficult and expensive process to bring it again to the upright position. One cylinder took an inclination of about 8 inches from the perpendicular when it was 25 feet in the sand; the first attempts to straighten it were made upon a very ingenious plan, devised and practised by Capt. William S. Smith, who had charge of the work before I had; it consisted in excavating quite to the bottom of the cylinder, and driving wooden wedges under the lower side, and applying a strain with a tackle purchase. When the pressure was allowed to escape, the cylinder would have a tendency to straighten; these efforts did not succeed, for the cylinder would not move at all.

I then arranged a purchase by which I could exert a strain of at least twelve tons, to pull the cylinder in the direction of perpendicular. The material was excavated to the bottom of the cylinder, and wedges were driven well under the lower side; the excavation was then extended outside of the cylinder on the upper side, so that the air would escape altogether on that side, thus loosening the sand which pressed upon the upper side of the cylinder. In addition to these appliances, I arranged a battering-ram on a small scale, by suspending a stick of timber so that its blows directed against the side near the top of the cylinder should tend to straighten it. Having all things prepared, I took the men out, and allowed the pressure to escape, at the same time "hauling hard" upon the tackle, but the cylinder did not move. I then had the ram brought to bear, and the effect was magical; the thirty tons of metal in the cylinder, under the combined action of the pressure, strain, and ram, yielded readily and was soon brought into position. The slight blows from the ram seemed all that was requisite to loosen the hold of the sand upon the cylinder, and allow it to move.

Incidents and Notes.—The amount of sand that entered the cylinder under the bottom when the pressure was allowed to escape, was

astonishing; on one occasion, when the cylinder had penetrated the sand twenty-one feet, and was nearly through the stratum of coarse gravel, the material having been excavated to the bottom, the pressure was allowed to escape: the cylinder sunk less than a foot, and the sand rose inside the cylinder 22 feet. This quantity = nearly 21 cubic yards, was brought in by the in-rushing water in a very few minutes.

During the process of sinking a cylinder 27 feet, there was the incredible amount of 129 feet in depth of sand excavated.

In several instances, 24 feet (in depth) of water was blown out of the cylinder; in ten minutes, 38,468 lbs. of water, were raised to an average height of 22 feet in ten minutes; and on one occasion, in one hour, we forced out through the syphon-pipe 15 feet in depth of sand, equal nearly 14 cubic yards, raising it on an average 32½ feet; this was done entirely by the pressure of the air.

At another time, the water had been forced out of the cylinder, and a few feet of sand excavated, so that the men were about 20 feet below the surface of the river, when the force-pipe burst. I was fearful for the effect it might have upon the men, both from the effects of the sudden removal of the pressure, and also the in-rushing of the water consequent upon it. I almost instantly procured a piece of rubber-packing, and, applying it over the rent, bound it fast with a cord, and was thus enabled, by running the pumps very rapidly, to hold a sufficient pressure in the cylinder for keeping the water out till the men were removed.

The men informed me that, as they were at work, they suddenly heard a loud report as of a cannon, and all was dark as night. The report was occasioned by the sudden removal of the pressure from the outside of the ear, while within, the air was condensed; the darkness was occasioned by a rapid condensation of the vapor, held in invisible suspension in the condensed air, forming a dense fog.

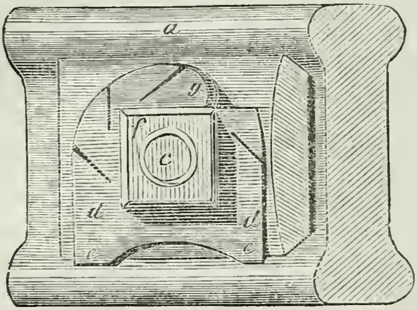
Tizard's Railway Bolt Fastener.

From the Lond. Mechanics' Mag., June, 1861.

A very important improvement has just been patented for preventing the bolts working loose in the permanent way of railways, the invention of Mr. W. L. Tizard, of Mark Lane, London, and which is intended more especially to refer to the nuts used to secure the "fishes" of the joints of rails. The nuts as now used require constant attention to fasten them up, owing to their becoming loose, consequent upon the action of passing trains.

This invention consists in the employment of a washer, one side of which is extended and has the edges turned down over the "fish-plate." A slit or series of slits are made in the washer, parallel with one of the sides of the nut, the piece between any two of the slits forming a tongue. After the nut is screwed up, one of the tongues is turned forwards, and thus the nut is prevented from turning.

The accompanying engraving is a face view, with the rail and fish-plate broken off. *a* is the rail; *b* the fish-plate; *c* is a bolt passing through the fish-plates and rail; *d* is the washer, placed over the threaded portion of the bolt *c*; it is by preference made of the best iron rolled into strips and cut the required size and shape; it has slits cut in it, as shown, whereby series of tongues are formed, and it is curved to suit the exterior surface of the fish-plate, the lower portions, *e e*, resting on the rail, whereby the washer is prevented from turning when the nut is acted on by the spanner; *f* is the nut screwing over the bolt *c*, and abutting against the washer *d*. To prevent the nut from becoming loose, turn up one of the tongues formed by the slits, as shown at *g*, against one of the flat sides of the nut, whereby the bolt is prevented from working loose. Instead of a tongue, the patentee sometimes turns up a piece of the washer, and drives a key or wedge between it and the flat side of the nut.



MECHANICS, PHYSICS, AND CHEMISTRY.

Filtration and Filtering Media.

[Proceedings of Society of Arts. May 1, 1861.]

From the London Chemical News, No. 78.

Mr. Julius Dahlke read a short, but on the whole, effective paper, at this meeting of the Society, on "Filtration and Filtering Media," of which we propose to sketch the more important points.

As we all know, filters, in some form or other, have been employed from a very early period, but the historical part of Mr. Dahlke's paper is very imperfect, and does not present a good view of the progress of the art of filtration, as it should have done, to carry out its title properly. Thus, while a casual mention was made by the Lecturer of the porous stone and earthenware filters of the ancient Egyptians and Chinese, the early Roman arrangements for this purpose were not even named, nor were the more recent processes of Peacock, Paul, Rommerhausen, Thom, Leloge, Sterling, Beart, Murray, &c., referred to in any way. As regards the scientific aspects of filtration also, Mr. Dahlke is equally deficient, but as other parts of his paper are not without merit, we proceed to quote the same.

"During the past seventy years, gravel, sand, and charcoal, used as a mixture, have been the agents most in vogue amongst filter makers, and it is only lately that due attention has been paid to charcoal as the most efficient filtering medium. Its use is much more frequent now, because not only has it a powerful detergent effect, but it

possesses also the peculiar advantage of not becoming foul, while it protects from decomposition other bodies in contact with it.

"It has been often asked why animal charcoal is so effective as a filtering medium? Some attribute this to the presence of so much carbon; but that this is an insufficient reason, is shown by the fact that, although coke contains more carbon than sand, yet it is not superior as a filtering agent.

"Animal charcoal filters about three-and-a-half times more rapidly than either coke or sand, while it is also greatly superior in this, that it removes many inorganic impurities held in solution, over which the former substances exert no power.

"It appears that the more porosity a filtering medium possesses in itself, the more rapidly does it filter, and the greater is the effect it produces on the water. The latter will be still more decided when, with a greater porosity, peculiar substances are combined.

"This leads me to believe that we may attribute the extraordinary filtering quality of animal charcoal to the fact that its principal component parts are lime and carbon, so combined as to secure a wonderfully fine porosity. Vegetable charcoal, although very porous, and containing far more carbon, has less effect on water.

"I have observed that another substance, of which I shall presently speak, and which (although of an entirely different origin) possesses great similarity in this respect, may in many cases be successfully substituted for animal charcoal. Indeed, there are doubtless numerous substances and compounds which may be used with as great effect. Do we not see that Nature supplies the most beautiful waters from limestone beds? It is hardly necessary to say, could we but imitate her action, that we should be able to do more in this as well as in other things, but we must content ourselves with as much success as our defective knowledge of her laws will permit us.

"Although we know of powerful agents for the removal of different impurities from water, circumstances may and do interpose which render it extremely difficult to obtain the medium in the requisite form for our purpose, and there is nothing yet discovered which will perfectly meet all the requirements of the case. Those who assert that it is possible to construct an apparatus to act as a universal filter for purifying any kind of water effectively, whatever may be the impurities, remind me of the vendors of certain patent medicines, who vaunt their nostrums as capable of curing every disease. Their claims are about equally trustworthy.

"I should classify the art of filtration into three systems, viz: 1st, where the action takes place simply on the surface of the filtering medium; 2d, where the whole bulk of the filtering medium is calculated to operate on the water, and the detergent effect in its most delicate form may be produced; and 3d, where both of these systems are conjointly employed.

"The first system requires a filtering medium of such a fine porosity that its pores must be smaller than the minute particles composing the impurities suspended in the water. Such an agent of course must

sooner become clogged, than a filtering medium of coarser porosity, and which is meant to act with its whole bulk on the water. But both systems employed together may prove to be useful in several instances, as in the case of domestic filters. The greatest failing of these is, that they must become clogged, and the more they are liable to this, the more effectively they act. We often hear of self-cleansing domestic filters, but the fact is that no invention of the kind has been made yet, without involving complications too great for the purposes of ordinary domestic use.

"However, it is not difficult to make a filter for general domestic purposes—although the effective self-cleansing of such an apparatus is still a problem to be solved.

"If the filtering medium employed in this case be solid, and of a fine porosity in its upper part, the clogging impurities will not only be retained on the surface, but may be easily removed by scraping; and then, if the lower part of the filtering medium be prepared of a material capable of producing a detergent effect, it will act the more readily through not being interfered with by the rougher and clogging impurities.

"It should be remembered, too, that in most cases we have here only to deal with some rougher impurities which have found their way into the water on its passage from water works, or other source, to the tap of the consumer.

"Being deeply interested in the subject of filtration, I have never omitted an opportunity of carefully inspecting those house-cisterns which came under my observation; I have, however, seen but few to which the attention necessary to secure the due cleansing had been paid. Most of them were loaded with mud, and in some of them I actually noticed the growth of vegetation (fungi*). I conclude, from my observations, that hardly one-fourth of the house-cisterns in London are in such a condition as to afford the consumer a supply of wholesome water like that which flows from the main.

"The difficulty, or I may say the impossibility, of keeping water which is stored in cisterns entirely free from accidental contamination, should lead us to provide a domestic filter capable of removing chemical impurities, as, for example, any lead which may be held in solution; in fact, the practice of filtering water preserved in cisterns and intended for domestic use, cannot be too warmly recommended.

"To remove lead from water, Professor Faraday recommends the practice of stirring up animal charcoal with the water so contaminated, the same being then allowed to settle. I have found, however, that, by using this material in a manner to be described hereafter, I never failed in producing the same effect by means of filtration.

"It is easy enough to purify small quantities of water, but the greater the quantity the greater are the difficulties of purification, especially when a certain chemical effect has to be produced.

"It will not be necessary for me to dwell upon the filtering processes required for large water-works, as the supply is generally taken

* Query—*Algæ* or *Confervæ?*

from such sources that the common sand filter-bed answers the purpose; and where the water is too hard for domestic uses, the beautiful process of Dr. Clark will meet and remedy the evil.

"Experience shows that it is not prudent to adopt the same means of purification for every kind of water, and I should make a difference in the treatment of the water used for domestic and that employed for manufacturing purposes. In the latter it will be often of the greatest importance to have the water as pure as possible, whereas certain so-called impurities in water may not be at all injurious to health. When we consider that no one would call human blood impure which contained 420 grains of saline matter per gallon, I do not know that we are justified (of course, speaking in relation to health) in calling water impure which contains small quantities of certain saline matters, particularly when we have no medical evidence that the small portions of them drunk in such water ever did any harm. Besides which, it should be remarked that the quantity of lime and magnesian salts drunk in water must be greatly exceeded in amount by that which enters the system in the food."

Mr. Dahlke had better have omitted this last paragraph, his knowledge of our language not being sufficient to show him the true signification of the words "pure" and "impure." There are a good many substances essential to the legitimate composition of our bodies that cannot be considered other than "impurities," if present in the water we drink; there is, moreover, abundance of medical and social evidence that large quantities of lime and saline matters in drinking water are productive of decidedly injurious effects, especially upon the skin, kidneys, and digestive organs.

Mr. Dahlke next said that "too pure water is distasteful, and unfit for drinking purposes," citing an illustrative case of some flat-tasting, remarkably pure water, which he had rendered more palatable by adding to it "some finely-dissolved organic impurities," and then filtering through animal charcoal.

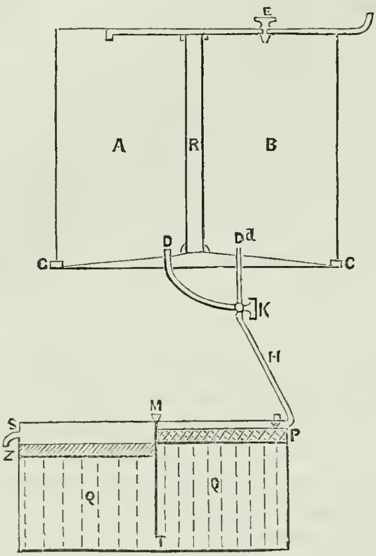
Our author prefers animal charcoal to all other filtering media, and regrets that no practical method is yet known of moulding it into blocks without diminishing its powers. Charcoal, he said, as regards its filtering qualities, stands to coke as 15 to 4, and all attempts at solidifying it by calcination with pitch, tar, &c., have failed in practice, owing to the glazing effects of the bitumen, which greatly impairs its action.

Mr. Dahlke's filter we shall shortly describe, as it appears to possess certain advantages over others of the same class that render it well worthy of notice; after various trials he found that the residue, after distillation, of the well known Torbane-hill mineral, with a small addition of fine clay, will, if saturated with fatty or oily matter,* and calcined, furnish a very powerful filtering medium, capable of reducing the hardness of water, and removing its color and odor. He also adds bone-dust, both to improve the quality of the "filter-blocks," and in order to regulate their degree of porosity with greater precision. We

* We would suggest blood, or milk, as more likely to answer the purpose.—Ed.

must now, however, permit Mr. Dahlke to describe his own filter more particularly:—

"Supposing 5000 gallons of water are daily required to be purified, that the water supplied contains nine grains of organic matter per gallon, has a bad smell, and is of seventeen degrees of hardness, I should employ an apparatus of which a wood-cut is here given:



"The upper part is a tank made from slate, completely closed, and is divided into two compartments by means of a solid filter block with one inlet, and one outlet for each of them. The supply-pipe is provided with a three-way cock, E, which allows the necessary arrangement to be made for admitting the water to one compartment of the tank, and for causing it to pass into the other through the filter-block. If, for instance, it enters at A, it has to pass through R into B, flow off by D[d], and through K and H into the second apparatus.

"This tank, being only intended to free the water from the rougher and clogging impurities, its action is to be reversed as often as may appear necessary in order to remove the collected sediment. This is easily done by shutting off the supply-pipe for A, and opening that for B; but before the water is allowed to enter the connecting pipe of the second apparatus, the accumulated impurities must be removed through the opening of the corresponding plug, G, and, that it may flow off easily, the bottoms of the two compartments are inclined towards the plugs.

"The two walls of the tank which face the filtering medium, are os fixed, that they can be opened from time to time, in order that the surface of the filter may be scoured, it being of such a consistency that its surface can be easily abraded by rubbing with hard stone.

"The water is thus freed from its coarser organic impurities, so far that they cannot possibly clog the second apparatus, which is thus retained almost entirely for chemical action on the water. It consists of a vessel which is also completely closed, with one inlet (W), and one outlet (S), divided from M to T, and fitted in the following manner:—P is a solid filter-block, cemented into the apparatus and covering the whole surface of the body, Q, thus forming the top part of this filter; it is of much finer porosity than the filtering-block in the tank, in order to separate the finer particles of organic matter from the water. The space, Q, is filled up with coarse granular charcoal and a preparation of the Torbane-hill mineral spoken of, intended to operate upon the water, so as to remove those matters held in solution which impart

color, smell, and hardness. Z is a solid filter-plate, of a more neutral character, also cemented into the vessel to hold, together with P, the packing of the apparatus.

"The reason why the two materials which fill Q are employed in a rather coarse grain, is, because the oxidation of several of the impurities taking place during the filtering process, will produce considerable quantities of gases, which would soon accumulate in a finer medium and interfere with the rate of filtration, wherefore I rather prefer employing the mixture in a thicker layer.

"The dimensions of the apparatus, and the different filtering media employed in this case, will be 3 feet square by 4 inches in thickness for the filter-block in the tank; each compartment of apparatus No. 2 to be 18 inches high by 2 feet square (internal measure); its fittings are, the plate, P, 3 inches thick, Q 2 feet, and Z 3 inches.

"The first clogging in apparatus No. 2 will take place on the surface of P, which can be easily avoided by removing the corresponding cover of the vessel, and rubbing the surface of P with a piece of hard stone, to which it will slowly yield, and thus be easily freed from its clogging matters, which cannot penetrate into it, the porosity of the filter-cake being too fine.

"The filter-block in the tank is so fixed that it can be taken out and replaced without much inconvenience, should it become worn out.

"The apparatus thus arranged is calculated for not less than 12 feet pressure, and its effect on such water as we supposed to have for illustration will be as follows: Organic impurities reduced to about half a grain per gallon, no trace of smell or color remains, and its hardness is reduced to about 7° or 8°.

"With regard to the continuance of the chemical effect, I admit that this must have its limits; however, from the fact that the rougher clogging impurities are so easily removed from the apparatus, and that the quantity of the inorganic impurities which will be absorbed must necessarily be comparatively small, a good portion of them escaping in the form of gas, I do not hesitate to assert that it can be successfully employed, for a considerable time, before the filtering agents get exhausted, and repacking is required.

"I do not believe it would be possible to work such a quantity of water so effectively and lastingly in such a small apparatus, if the whole of the filtering medium were to be used in a loose state, as its porosity in the latter case could not be condensed to the state of fineness required.

"This apparatus being only meant to serve for the special purpose I spoke of, it is obvious that it will have to be altered according to circumstances, both as regards the filtering agents to be employed, and its mechanical arrangements.

"If the quantity of water to be filtered be so great that a very large filter-bed is required, I prefer employing the preparation of the Torbane-hill mineral, as described, in a granular state, rather than sand; for this reason, that it filters more than three times as quick, and is five times as light as the latter; consequently a ton of it will, by a

layer of equal thickness, filter about sixteen times the quantity of water that a ton of sand would filter, with the advantage that the filtering would produce at the same time a greater decolorizing effect and a considerable softening of the water. A clogging from the precipitation of chalk is not likely to take place, as this substance is separated in a crystalline and granular state. Moreover, those particles of the material which become saturated with organic impurities may, through calcination, regain the greater part of their former efficiency."

Omitting the concluding paragraph of the Paper, which is unimportant, we have now to present to our readers the "cream" of the discussion which followed.

Mr. Spencer rose first, to deliver a speech, of which the chief object seemed to be, to lay claim to Mr. Dahlke's invention or application entirely. He had broken open one of the filters in question, and found the filtering medium contained about ten per cent. of the magnetic oxide of iron, to which, he said, all its virtues were due. He had determined (quantitatively?) the presence of this substance by means of the magnet, and accused the author of the paper of infringing his (Mr. Spencer's) patent.

Mr. Atkins set forth the merits of "carbon" *per se*, as a filtering agent, of which he had manufactured some 40,000 or 50,000 blocks, and proceeded to praise the Moulded Carbon Company and their manufactures in high terms.

Dr. Waller Lewis bore testimony to the efficacy of the filter supplied by Mr. Dahlke to a very large public department, as to its powers of deodorizing and decolorizing water. It was new to him to hear that too pure water was distasteful; and he was afraid Mr. Dahlke was assuming an untenable position. He thought inhabitants of towns were no judges of water, as their palates were disorganized by the impure water supplied to them. He had tasted the water of Lake Bala in North Wales, containing only 1½ grains of mineral matter per gallon. Many persons did not like it at first, if they had been accustomed to London water.

Mr. Painter dwelt upon the good qualities of a mixture of silica and carbon, and of the balls of the Moulded Carbon Company. These balls were cleaned by blowing air through them—a superior plan to that of Mr. Dahlke, he thought.

Mr. Danchell preferred animal charcoal to any thing else, and had abandoned all other filtering media.

Mr. Wentworth Scott said he had been called upon to make various experiments upon the relative merits of animal charcoal and prepared carbons of several kinds, as regards their power of absorbing organic matter, which resulted in favor of the first-named substance. The Moulded Carbon Company's balls were subject to the defect of having in many cases their central cavity greatly on one side, thereby modifying their action injuriously. He recommended the *platinizing* of the balls—a simple process—for waters containing much organic matter.

Mr. Morgan remarked that the public were the best judges of filters in the end. He regretted that scientific discussions were so frequently

sullied by personalities, and commented severely, but justly, upon Mr. Spencer's speech.

After a brief reply from Mr. Dahlke, a vote of thanks was passed to him, on the motion of the Chairman, for his paper, and the meeting then adjourned.

For the Journal of the Franklin Institute.

On the Erie Experiments on Steam Expansion by U. S. Naval Engineers. By SAMUEL MCELROY, C. E.

During a part of the months of November, December, and January, of last winter, experiments were made at Erie, on the U. S. Steamer *Michigan*, under order of the Secretary of the Navy, by a Board of Chief Engineers of the Naval Engineer Corps, to determine certain questions in reference to the economy of steam expansion. Previous experiments made by the chief officer of the Board, had induced him to assert the fallacy of the commonly received doctrine of economy in expansion, and these observations were undertaken to pursue the investigation on a more perfect engine, and with greater care. A report of the results has been published by the Navy Department, of which a synopsis at length is given in the April number of this Journal, by a member of the Board.

The conclusions reported by this Board are of a very radical and revolutionary character, so far as they affect principles which have been accepted in practice from a very early period in the history of the steam engine applied to actual work. They differ from the whole tenor of experimental observation and theoretical deductions, and if accepted by the profession, would modify at once our proportions of working parts, and our applications of power. Their argument as to the economy of expansion is contained in the following quotation from the report:—

"The results obtained from this engine are rigorously applicable to all others in which saturated steam is employed in a cylinder not steam jacketed, and show conclusively the utter futility of attempting to realize an economical gain in fuel under such conditions by expanding the steam beyond the very moderate limit of one-and-a-half times; and that, if the expansion be carried to three times, a positive loss is incurred. Also, that if measures of expansion as high as those due to cutting off the steam at $\frac{1}{6}$th or $\frac{4}{45}$ths of the stroke are employed, the economy is considerably less than with steam used absolutely without expansion." It is also stated, in those cases where a reduction is to be made in power, on a cylinder cutting off at the "economical limit of $\frac{7}{10}$ths," that, as to a choice between a closer cut-off and the use of the throttle, "in fact, the two modes of reducing the power may be considered equal in rapport of economy of fuel; but, in every other respect, the choice is immeasureably in favor of the throttle valve."

Language of this kind admits of no misconstruction. It throws the gauntlet at the foot of universal professional opinion and practice boldly and unequivocally. It declares that in all ordinary working

cylinders, not steam jacketed, there is no gain in cutting off closer than at two-fifths, and that a positive loss follows a cut-off at one-quarter stroke. It is better to carry full steam, we are told, than to cut off at one-sixth. And farther than this, it is better to throttle the steam for any reduction inside of seven-tenths cut off, than to cut off with the main valve.

An opinion of this kind, expressed in this way, has a certain gravity, and merits an attention which might be denied the publication of any individual conclusion to the same effect. It claims to be issued by authority, it involves the honor of the Naval Engineer Corps, it passes out to other countries as the conclusion of American science, and it pretends to be infallible. This Board informs us that its report is "only one more illustration of the well-known fact that the histories of all sciences are but records of mistakes and misconceptions, arising from the application of fallacious theories, which, once plausibly advanced, were long believed in, from an unwillingness to investigate for ourselves, but which exploded at the first touch of the *experimentum crucis.*" It is a matter, therefore, of some interest to the profession to inquire how far this assumption of new light will in itself bear the test which is claimed to have been applied, for the first time, to all the past.

We may justly, then, in our examination of these opinions and the experiments on which they are based, subject them to severe analysis, in order to detect any sources of error. All revolutions, political or scientific, must be content to bear the burthen of proof, and cannot be allotted the benefit of any doubts. If, in ordinary processes, according with established principles, we may leave unquestioned between the initiative and the final result many of the intermediate operations, it is manifest that nothing of the kind can be claimed or allowed in a case like this, which seems to contravert well-known and long-established mechanical laws. And we have, therefore, a right to determine that this report shall only be accepted, if its experiments were correct as to the principle of experiment, the method of experiment, and the most consistent and conclusive results of experiment. Any contradictions occurring at any stage of the process, any palpable or possible errors in process, any anomalous results or inferences, are fatal to the whole, and must be so received. The first great lesson which a thorough-bred engineer learns, is to take nothing for granted; and however we may personally respect and value the character and experience of the members of this Board, we must judge of their verdict by fixed and positive conditions of analysis, and in no other way. If they have failed to determine with rigid accuracy a single important link in the chain of evidence, the report falls to the ground; and if processes in detail are suppressed, requisite to establish evidence, the argument of the report is, so far, vitiated.

The reader of this report cannot fail to be impressed with its parade of accuracy. Elaborate descriptions are given of certain precautions taken, and sizes in close detail of the boilers and engines are recorded with interesting fidelity. The precise number of inches between the

bottom of the feed-water tank and the floor is not omitted. Equally elaborate are the arguments on the results obtained, both which features comprise a report of some 38 pages. But when, with some educated regard for such matters, we examine this report for the *notes of the experiments* in similar satisfactory detail, we are surprised to find them entirely omitted, and have no key to them whatever, except the aggregated results given in two tables, arranged in seven columns, allotted to as many distinct experiments. These tables are merely averages and aggregates of the results in detail, and therefore define the several processes in a general way. To have known precisely the times and manner of coal supply, tank supply, cleaning fires, starting and hauling fires, variations of pressure, and the like, as to the boilers, we might well have excused an elaborate notice of the kind, material, and diverse sizes of their flues, or any other matters irrelevant to the questions at issue. And this remark is applicable to all the other processes tabulated. The counsel for the defendant has no opportunity to cross-question the witnesses. The argument is confined to the general allegations. We do not mean to convey the impression here that these tables are incorrectly reported, but we do intend to say, that the report has a pretension of accuracy in detail which is not warranted by its actual statistics of essential points. It does not enable us to decide any questions suggested by the tables themselves.

The correctness of the opinions expressed by the Board is to be judged by the results obtained by it, so far as the course of examination adopted was in itself correct. If any objections exist as to any portion of such course, they invalidate, in proportion to their character, the results obtained. The first point, then, to be considered, is the Course of Experiment pursued.

The following general description of method is deduced from the statements of the report:—

The ship has two engines and two boilers. The starboard engine and both wheels were used, with *both boilers*, for all the trials reported, the port engine being disconnected.

The boiler evaporation was determined by indicator cards taken hourly, and by tank measurements.

Each experiment continued precisely 72 hours; there being 7 reported with a steam travel in the cylinder varying from $\frac{11}{12}$ths to $\frac{4}{45}$ths.

The boiler pressure was nearly uniform in all the trials.

The ship was secured to the wharf, so that the wheels paddled the water aft.

Before an experiment, the engine was operated for several hours. When all was ready as to water level and boiler pressure, with "average fires," the notes were commenced. At the close, the boiler level was corrected, and the fires made the same "as nearly as could be estimated." The friction and resistance of the engine and wheel-arms and rims, were determined by taking off the floats, and working the engine from 6 to 22 turns, taking indicator cards to obtain a reliable mean for each rate of speed.

During an experiment, the engine was neither stopped, slowed down, nor in any way changed in condition.

Due precautions were taken as to the tightness of valves, &c., correctness of counter, coal account, and other important notes.

To illustrate more fully the course of experiment adopted, the following abstract is made from table No. 1 of the report, which gives the "data and results." Table No. 2 equates these results in various ways, and is based on No. 1.

No. of experim't.	Date of commencement.	Boiler gauge pressure.	Mean cylinder pressure.	Vacuum.	Cut-off.	Revolutions.	H. P.	Coal per sq. foot of grate.	Coal per H. P. per hour.	Feed-water per lb. coal by tank.	Kind of coal.
1	Dec. 30, 4 A. M.,	21	19 9	25·8	3-10	13·69	133·7	6·28	4·23	8·33	Ormsby.
2	Jan. 2, " "	"	13·6	25·6	1-6	11·17	74·5	3·79	4·58	8·09	"
3	" 5, 6 "	"	17·4	25·8	1-4	13·87	118·4	5·21	3·96	8·70	"
4	" 8, 10 "	"	24·1	26·3	4-9	17·28	204·4	9·51	4·19	7·90	"
5	" 18, " P. M.,	19·5	27·6	26·1	7-10	15·56	210·8	11·41	4·87	7·14	Anthracite.
6	" 21, 12 "	21	29·8	26·5	11-12	20·61	301·4	18·52	5·53	7·22	Brookfield.
7	" 25, 6 "	22	8·8	24·1	4-45	14·10	60·9	4·11	6·08	7·58	Ormsby.

Notwithstanding the claim of this report that it is the "*experimentum crucis*" which has, for the first time, successfully opposed rigid experiment against "fallacious theories," we shall assume here, that there are certain general principles by which its particular course is to be tested, which overrule any experimental results, and decide the question of acceptance or rejection by positive laws.

We shall not pause here to defend this assumption by any argument at length. It is a great mistake to assert, in these latter days, that engineering is a science hitherto purely theoretical. On the contrary, it is clear that its laws have been gradually determined from the absolute results of long continued observations, and eliminated from the unmistakable precepts of actual trial. This is the glory of the profession, that from known results it has framed its precepts and laws, under the guidance of which, in certain established methods, it may claim infallibility, without arrogance. And it is the leading principle of the profession, that all conjecture and discussion should be brought to the test of trial and by such test to stand or fall. There is no need of multiplying words or adducing evidences of so well known a statement as this. Every engineer who has had to assume the responsibility of important constructions, knows by experience that it is true.

As appears from its report, the Board, in experimenting, adopted a uniform standard of low boiler-pressure for all the variations of work, and changed the resistances of the wheels by removing the floats. For all grades of expansion then, low steam was used, a uniform initial pressure, and variable resistances.

We object to the correctness of this method, for the following reasons:—

The problem which presents itself to an engineer in operating his engine and his boilers, is defined by the amount of work to be done

and the most economical method of doing it within limits of safety. And with a given engine in place, like the *Michigan's*, the argument between expansion and non-expansion should have been determined by a fixed standard of piston resistance, and not by a fixed standard of boiler pressure, with variable resistances. Viewed in this light, which is the only correct one, the mission of this Board was to experiment, first on such a boiler pressure as with a full steam stroke would fulfil the usual duties of the engine, and then maintaining the same *average cylinder pressure*, and the same engine duty, to test the economical results with successive degrees of expansion, and corresponding increments of initial pressure. This is the real matter at issue—whether it is cheaper to carry high steam and expand, or to carry low steam and follow at full stroke.

As to its opinion on this subject, the Board, in a part of its report, leaves us distinctly to infer that its results, as tabulated, are conclusive against the use of higher steam. Its argument, as given on pages 33 and 34, is based on the assumed fact that it has demonstrated an immense loss in any high range of expansion, and it follows by consequence, that a greater boiler pressure, as involving a closer cut-off, would be useless. Unfortunately for our confidence in its tables, which will not be found to bear analysis, it has not favored us with any practical demonstration of its singular logic, and as it seems to be simply Quixotic to pause here, for the purpose of establishing the proposition which is plain to the rudest coal-heaver, that it is cheaper to make high steam than low steam, we content ourselves at present with saying that this neglect, in itself, as a misapprehension of principle, is sufficient to overthrow all these carefully eliminated tables and high toned results. The relative economy of high and low pressure for a given amount of work has long since passed beyond the region of conjecture. Those of us who have seen engines of enormous contract value, hanging for acceptance or rejection on the rise of the boiler gauge, and the curve of an indicator card, know something of this in practice, and by demonstrations of the highest order.

Again, we find in these experiments, that with the same pressure and the same grate surface, the rate of combustion in the boilers varies from 18·52 pounds per square foot to 3·79.

In this way the Board disposes in a very summary manner of the discussion which has long agitated the engineering world, as to the relative merits of quick and slow combustion. While one class has claimed superior advantage in slow combustion, and has specially adapted its boilers to this process, their opponents pronounce in favor of quick combustion, and modify their forms accordingly. The discussion also embraces varieties of coal, one being deemed most suitable for a slow fire, and another for a stronger fire. Volume after volume, experiment after experiment, debate after debate, are extant on this subject. But here, without argument or apology, this "fallacious" range of opinion is laid upon the shelf, and in the same boilers, with the same variety of coal, the rate of combustion is varied about *four hundred* per cent.! And the highest rate is that required, of all these,

for the ordinary speed of the ship, for which these boilers were proportioned. The tabular results of this board, then, are just as valuable and just as conclusive on the theory of variable combustion as they are on that of variable expansion.

It has been claimed, and demonstrated by experiment in important cases, that the proportions and conditions of a boiler being constant, there can be but one rate of combustion in correspondence with its *maximum useful effect.* This is a recognised law of practice, and is true of either a quick or slow combustion boiler. Farther than this, it has been claimed, that the *useful effect* of a boiler is modified by the manner in which its steam supply is taken, whether more or less rapidly, and in approximation to a certain rate of supply. But the course of experiments under examination exercises a supreme contempt for these distinctions. Not only is the rate of combustion varied, as we have stated, but the rate of steam supply, in equal times, varies *six hundred* per cent.! The performance of these boilers, judged by the results tabulated, does not reach, by at least 25 per cent. of evaporation, the standard of reasonable expectation, and in no two experiments is the evaporation alike per pound of coal. When we are told that special care was exercised in all the experiments to keep the throttle open, although the Board claims to have demonstrated certain singular conclusions about throttling, we can readily understand with what ingenuity these boilers were themselves throttled out of their vitality.

The doctrine of *maximum useful effect*, which defines the load and the velocity of an engine is also placed at issue here. Theory has been confirmed, in repeated instances, as to this law, which has engaged the attention of our most profound students. A certain standard of proportion exists between the leading features of an engine and the amount of labor it will best perform, and no violence can be done any of its conditions of service without detrimental results.

The steamer *Michigan*, as a case in point, was built for Lake service, with a certain proportion of machinery to her displacement and speed. From notes of her performance, we find that with a mean piston pressure of 18·44 pounds per square inch, she makes $18\frac{1}{3}$ revolutions per minute, and 10·4 statute miles per hour. As a side-wheel steamer, with two engines and two boilers, these are her ordinary conditions of work. But, in experimenting with her, all these relative proportions are violated. One engine is disconnected, and both boilers are kept under fire to supply the other, although with the same initial pressure the revolutions are varied from 20·6 to 11·17, and the mean pressure (a representative of the load) is changed from 29·8 to 8·8 pounds per square inch. And yet the Board seems to be under the impression that all these changes are compatible with a common standard of useful effect, and practically denies a most important principle of mechanical action. In this respect we are not prepared to concede its infallibility.

In connexion with this objection a question of fact arises, as to the literal accuracy of the report. The Board attempted to carry out a

mistaken principle of trial by regulating the resistances of the wheels, so as to accommodate a uniform initial pressure, and it succeeded very completely in producing a variously diseased and incongruous action of the engine; but it is incorrect in asserting that it "was not in any way changed in condition" of motion during any experiment, inasmuch as the waves were affected by the wind, and the dip of the floats varied as the vessel alternately grounded or floated, and the floats themselves were, from time to time, broken by ice. These resistances, by consequence, could not have been uniform during any experiment.

A glance at the tabular synopsis sufficiently indicates the effects of these variable resistances. The results in action are much more diversified than the changes in rate of expansion, and are strikingly inconsistent. A mean pressure of 8·8 pounds produces 14·1 revolutions, while that of 13·6 pounds gives only 11·17 turns. We increase the pressure 60 per cent., and it reduces the speed 21 per cent. A range of 603 per cent. has been noticed in the quantity of steam used in a given time; there is a range of 240 per cent. in the mean pressures; a variation of 10 per cent. in the vacuum; of 84 per cent. in speed; of 390 per cent. in combustion; of 50 per cent. in coal per H. P.; of 22 per cent. in evaporation.

And the argument of the report is embarrassing in these conflicting cases. There stand the tables of the new law. Whatever opposes their "data" is "fallacious," and it is just as incontrovertibly true, that an increase of pressure will reduce speed in all engines not steam-jacketed, as it is that it is cheaper to follow full stroke than to cut off at one-sixth.

On page 13, the report states that "during all the experiments the throttle valve was kept wide open." On pp. 36 and 37, we have the argument, already quoted, that for anything below a steam travel of seven-tenths, it is "immeasurably" better to throttle than to use the main valve.

Here the Board, not having experimented, passes into the dangerous region of "fallacious theories," and jeopardizes its infallibility. Engineers are under the impression that the moment of final pressure determines the amount of steam expended during an engine stroke. And it is a simple mechanical impossibility that the same *mean pressure* in connexion with a given *final pressure* can be produced, where the throttle is used instead of the main valve cut-off. All experience goes to confirm the very plain principle that throttling reduces the initial range of pressure, and consequently the mean pressure, which determines the amount of work done, while the final pressure, which measures the cost of the work, remains constant in either method; and there is therefore a loss of power equivalent, at least, to such reduction of pressure. An assertion of opinion, like that quoted, coming from such a source, cannot but be regarded with surprise. Not only is it incorrect as to economy of fuel, but in all well arranged engines, it is as easy to modify the cut-off gear as to change the throttle. There may be an exception in the case of those horribly proportioned guillotines with which the Navy steamers have been afflicted of late years;

which have 6 inches clearance and 54 inches diameter for 32 inches stroke; which spin around sixty-five times a minute to achieve eight knots an hour; and of which an "assistant" stands in mortal fear, from the time they are "hooked on" until they happily break down, and are laid up for repairs.

It was to be presumed that the Board would trace their special theory through a regular series of demonstrations to a final conclusion in their method of experiment. But our table shows that no order of this kind was observed in the variations of expansion, as its report also shows that it argues on certain grades, which it did not test. Experiment No. 7 in date, as the greatest in grade, immediately succeeds that of the greatest steam travel, and the relative order of the series, in this respect, is Nos. 6, 5, 4, 1, 3, 2, 7, as distinguished from their dates. If the results obtained developed a regular series, we might be content to accept them, no matter in what order of precedence, but these are as irregular as their order of trial. The consumption of coal per H. P. per hour is thus reported: 3·96 lbs. for $\frac{1}{4}$ cut-off, 4·19 lbs. for $\frac{4}{9}$ths, 4·23 lbs. for $\frac{3}{10}$ths, 4·58 lbs. for $\frac{1}{6}$th, 4·87 lbs. for $\frac{7}{10}$ths, 5·53 lbs. for $\frac{1}{12}$ths, and 6·08 lbs. for $\frac{4}{45}$ths. Such a result as this, taken in connexion with the fact that the last trial shows about three times the combustion per H. P. due to some engines, is a painful commentary on the method of experiment adopted.

We may also observe here, that a number of experiments were made at Erie, which are not given in the report. The Board convened Nov. 19th, and the first result tabulated bears date Dec. 30th, although notes of experiments on the 1st, 5th, 8th, and 10th are extant. Of these the Board remarks, that "it is useless to add any others (to those given) which *uncontrollable variations* in the conditions during their progress could lay open to a doubt," although they are said to have shown less effect from the measures of expansion. The inference to be drawn from this omission, on these grounds, is by no means an argument in endorsement of the report, nor does it sustain the general *modus operandi*. Details of experiments are not only suppressed, but whole experiments themselves, probably equal in number to those given, are also suppressed. The witnesses do not tell the "whole truth."

Nor does the text of the report accord with the "data" tabulated, in an important matter of fact like the following:—

On page 12, we are told that "Each experiment lasted 72 consecutive hours, during which the engine was neither stopped, nor slowed down, nor in any way *changed in condition*. In commencing an experiment the engine was operated for *several hours* to adjust it *to the normal conditions* required to be *uniformly* maintained during that experiment, and to bring the fires to steady action." But when we turn to the tables which form the basis of the text, we find that while Experiment No. 1 terminated its 72 hours run at 4 A. M., Jan. 2d, Experiment No. 2 commenced at precisely the same moment. We also find that there was but two hours interval between Experiments Nos. 2 and 3, and 5 and 6. In a simple matter of fact, then, three experi-

ments out of the seven are open to discussion, as to the statements of the text.

But this is not the most serious point of this objection. It will be noticed that the combustion of coal per square foot of grate is 6·28 lbs. for No. 1, and 3·79 lbs. for No. 2; that the evaporation varies from 8·33 lbs. per lb. of coal to 8·09; that the mean cylinder pressure (which reveals a varied resistance) changes from 19·9 lbs. to 13·6, and the cut-off from $\frac{3}{10}$ths to $\frac{1}{6}$th, or as 18 to 10, and the revolutions from 13·69 to 11·77· Now we would like to be informed by what medium, unrevealed to ordinary philosophers, this Board was enabled to change the combustion of the boilers 51 per cent. in rate, at the tick of the second-hand which changed Experiment No. 1 to No. 2, and by what process they defined all the other changes of resistance and methods of action, which clearly distinguish these experiments. Their special claim of accuracy cannot meet the argument of this self-evident tabular conviction.

The Board suppresses a number of experiments on account of "uncontrollable variations." In those which they present we find that—

There is a variation in the boiler pressure from 19·5 to 22 lbs. per square inch.

There is a variation in the vacuum from 24·1 to 26·5 inches.

There is a variation in the evaporation per lb. of coal from 7·14 to 8·70 lbs. of water.

There is a variation in the coal used, three kinds being reported.

In matters of simple management like these, the discrepancies are inexcusable, and tend to complicate the results needlessly. Especially is it strange that different kinds of coal should be admitted under any circumstances, the variety used for the greatest steam travel differing from that in any other experiment.

(To be Continued.)

On the Nature of the Deep-Sea Bed, and the Presence of Animal Life at Vast Depths in the Ocean. By Dr. G. C. Wallich.

From the Lond. Engineer, No. 279.

Our first clear glance at the floor of the ocean may be said to date from the period at which submarine telegraphy was first undertaken. For although the depth of the sea has been approximately ascertained over widely extended areas, in the course of the various surveys conducted under the auspices of the British, the United States, and the Dutch governments, hardly any previous attempts have been made systematically to investigate the characters and composition of its bed. In the absence of any special object, such attempts would have been far too costly and difficult to be practicable. It has been ascertained, however, that the floor of the ocean is but the reflex, as it were, of the dry land; that it is in no place unfathomable; that along its deeper portions certain muddy deposits are to be met with, in many cases made up, more or less entirely, of minute calcareous shells belonging

to one of the most simple order of beings with which we are acquainted; and that together with these are also to be found, but in, comparatively speaking, small quantity, the minute flinty skeletons of other organisms derived both from the animal and vegetable kingdoms. But no conclusive evidence has been produced to show whether any or all of these organisms normally lived and perished, at the profound depths from whence they were obtained by the sounding lead; or whether, having inhabited distant and, perhaps, shallower seas, their dead remains alone, after being transported by currents, or other agencies, had gradually subsided into the deep hollows of the ocean. Taking into consideration the very important part played by these organisms in the structure of the earth's crust, that vast strata have, in ages gone by, been built up of them, and that similar strata are at the present time being deposited along the beds of existing seas, the investigation of these questions becomes of the highest consequence, as bearing on the successful establishment of ocean telegraphy.

The distribution of animal life in the upper waters of the sea, is determined by climate, by the composition of its waters, the nature of its bed, and its depth in any given locality; the last of these items necessarily involving the relative degrees of temperature, light, æration, and pressure, as compared with those to be met with near the surface. Of these conditions, climate exercises a very powerful influence; for it is found as we advance from the equator towards the poles, that a gradual diminution takes place, not only in the number of types met with, but of the varieties ranged under those types. It has been maintained that, in order to compensate for the diminution in the number of generic forms, the number of individuals of each species is much augmented. Although this law holds good as regards the higher orders, it can hardly be said to do so in the case of the lower; for the vast assemblages of these lower forms met with on the surface of the sea in the tropics, are in no wise less extensive than those met with in high latitudes. It will be found that, the lower the grade of being, the more equally balanced will be its distribution at the extremes of the globe; inasmuch as the greater range in depth commanded by these lower forms renders them less amenable to conditions which are variable from being dependent on atmospheric changes.

The composition of the waters of the ocean is well known to become much more equable at great depths; and it, therefore, exercises a far less marked influence on the presence of animal life than it does at the surface. The same causes which equalize the temperature in so remarkable a manner as the depth increases, are effective in equalizing the relative proportions of the various ingredients that enter into the composition of sea water, in all latitudes. For whilst the surface stratum is subject to dilution with fresh water, from various sources, the greater the depths the less subject can the waters be to this influence, and the less can it operate in modifying the distribution of the organisms that frequent them.

Oxygen is essential to the presence of animal life—without it ani-

mal life ceases. To air-breathing as well as water-breathing creatures, a due supply of this gas is indispensable; the function of respiration, no matter whether performed by lungs, as in man and the higher orders, or by a simple process of absorption and exudation through the general surface of the body, as in some of the lower forms, being in every instance essentially that process whereby oxygen is received into the system in exchange for carbonic acid, which is given off. But although oxygen enters largely into the composition of both atmospheric air and water, the supply of this element is not obtained, in the case of creatures inhabiting the sea, under ordinary circumstances, from its decomposition, but from a certain portion of atmospheric air present in water in a state of solution. Most gases are absorbed by water. Under pressure, the quantity absorbed is much increased, as is seen in the familiar case of soda-water. It should be borne in mind, however, when the fact is applied to the occurrence of animal life at great depths in the sea, that, in order to produce the absorption of atmospheric air, its contact or mixing together at the surface by the action of wind and wave is necessary, and the effect of this operation can only extend to a limited depth, unless, as has been assumed by some of our highest authorities, the lower strata of sea water, being subject to increased pressure, becomes capable of holding in solution a greater quantity of oxygen; and, by robbing the superincumbent strata of that which they contain, gradually become saturated with it. Should this view be correct, there must be a point at which the maximum amount of oxygen which sea water can absorb is permanently present in it. But, inasmuch as the vegetable cell, simple though it be in structure, can eliminate carbon from the medium in which it lives, it is not unreasonable to assume that the lowest forms of animal life, even where no specialized organs are traceable, may, in like manner, be able to eliminate oxygen directly from the water around them.

The temperature of the sea is materially influenced by the climatic conditions of different latitudes; and, of course, exercises a powerful effect both on the distribution and abundance of the higher orders of living beings present in its waters. But, as has been shown, this influence is not manifest, or, at all events, not so manifest in the lower orders; for, at great depths, the variability of the temperature is reduced within very narrow limits in all latitudes. Now, the higher orders of oceanic creatures inhabit only the surface waters, never sinking down to extreme depths. In the case of some of the lower forms, on the other hand, a very extended bathymetrical range exists, putting out of the question those which constantly dwell on the sea bed itself, of which I shall presently have to speak.

In like manner, light, or rather the absence of it, can hardly be said to determine, in any important degree, the distribution and limitation of the lower forms of animal life. Light is not essential, even in the case of some of the higher orders. A large class of creatures, both terrestrial and marine, possess no true organs of vision, although there is good reason for believing that they do possess some special

sensory apparatus, susceptible to the influence of light; whilst certain creatures, whose habitation is in subterranean caves or lakes, as in the Magdalena caves near Adelsburg and the Great Mammoth caves in Kentucky, either possess no organs of vision, or possess them in so rudimentary a state as to prove clearly that the absence or imperfect development of this sense may be compensated for by the higher development of other senses.

It is impossible at present to say to what depth light penetrates in the sea. The photographic art will, no doubt, one day solve the problem. But it is almost certain that a limit is attained, and that moreover long before the deep recesses gauged by the sounding machine are reached, where the light-giving portion of the ray cannot penetrate, even in its most attenuated condition; and yet, as shall hereafter be shown, creatures have been found down in those profound and dark abysses, whose coloring is as delicate and varied as if they had passed their existence under the bright influence of a summer sun!

Pressure is the last condition which has to be noticed. Although undoubtedly a highly important one, I hope to be able to prove that it is not of essential value, as has heretofore been laid down, in determining the final limit of animal life in the sea.

It is almost needless to state that, at the sea level, there exists a pressure of 15 lbs. on every square inch of surface, due to the weight of the atmospheric column resting upon it; and that the pressure on the successive strata of water in the sea, as the depth increases, is infinitely in excess of this, inasmuch as a column of water only 33 ft. in height, is capable of counterbalancing the entire atmospheric column, which extends to a height of about 45 miles. Accordingly, for every 33 ft. of descent in the sea, putting out of consideration the effect of the superincumbent column in actually diminishing the bulk of the portions beneath by augmenting their density, there is an additional 15 lbs. At great depths, therefore, the aggregate pressure becomes stupendous. As is well known, pieces of light wood let down to a depth of 1500 or 2000 fathoms, become so compressed and surcharged with water as to be too heavy to float. But there is a fallacy in this experiment; for the contraction of the woody fibre and cells is a necessary consequence of their submission to an amount of pressure so enormously in excess of that under which they originated. With organisms which have been developed, from first to last, under the full operation of any given amount of pressure, the result would not be of this nature; for the equalization of the pressure within and without their entire structure, although it might possibly exercise some definite effect in determining their shape, size, or even functions, cannot, I submit, operate in causing the creatures living under it to experience any more detrimental results than we experience from the 15 lbs. on every square inch, or about 14 tons on the general surface of our bodies, near the sea level.

It can scarcely be wondered at that, under such apparently extraordinary conditions, the maintenance of life, even in its least developed aspect, should have been deemed absolutely impossible at extreme

depths; and that it should have been almost unanimously recognised as an axiom, that, at a depth of 400 or, at most, 500 fathoms, life, whether animal or vegetable, must be extinct. The fact is unquestionable that, as we descend beyond the first hundred fathoms, the traces of life become more and more remote; and it is probably owing to this gradual diminution in the number of animal forms, as the depth exceeds this limit, that it has been assumed, rather as a matter of theory than of observation, that a point is speedily reached at which all the conditions essential to life are extinguished. This view has also derived support from the idea that "animal life depends on the previous existence of vegetable life." In the case of the higher orders of the animal kingdom, the law, no doubt, holds good. Not so, however, in the case of the lower. The conditions essential to the perpetuation of the one are not essential to the perpetuation of the other. Thus, light is indispensable for the healthy respiration and growth of the vegetable. The animal can, on the other hand, respire as freely in the blackest darkness as in the broad glare of day. And this is, no doubt, the reason why vegetable life in the ocean attains its final limit in depth so much sooner than animal life. And yet, considering how very unexpectedly animal life has been proved to exist deep down in the ocean—as I shall immediately show, far removed beyond those conditions which had hitherto been considered indispensable—we ought perhaps to pause before we assert that the same plastic skill which has so constituted certain creatures as to admit of their inhabiting the deep abysses of the ocean, may not, in like manner, have so constituted some of the vegetable organisms as to be capable of living under similar conditions.

(To be Continued.)

On the Employment of Lighting Gas in Acieration. By M. Gruner.

From the Lond. Chemical News, No. 82.

In the *Comptes-Rendus* of the 11th of last March, M. Fremy put the question to metallurgists whether his experiments relating to the conversion of iron into steel by means of lighting gas could not be practically utilized. In the name of metallurgists, let me be permitted to reply, that practice has long since positively decided this point.

Twenty-five years ago, Mr. Macintosh, an ingenious Glasgow manufacturer made several tons of cemented steel by submitting iron, at a dull red heat, to the action of lighting gas, operating with from 100 to 150 lbs. at a time, the iron bars being two inches broad and six lines thick. The cementation took from eighteen to twenty hours, and when the operation exceeded that time, supercarburation took place.

M. Dufrénoy published these details in the third series of the *Annales des Mines*, vol. v., p. 171. He had himself seen specimens of this steel, a portion of which was melted and then worked by the ordinary means. M. Dufrénoy says that the supercarburated thin bars nearly resembled graphite. Thus, then, by the sole action of lighting gas, without mixture of any foreign body, it is possible to obtain

either steel or cast iron; it is only a question of time or temperature. To obtain steel, there is no need to add ammonia previously in order to nitrogenize the iron. In fact, as M. Caron judiciously remarked, at the meeting of March 18th, coal gas always contains ammonia, and it is not my intention to deny its influence on cementation. I will not further attempt to solve the question of the presence or absence of nitrogen in steel; but it appears to me certain that, if nitrogen exists in steel, it exists equally in cast iron. Moreover, it is twenty years since Dr. Schafhaütl of Munich stated positively that he had found nitrogen in cast iron.

It must be remembered that, in ordinary cementation with wood charcoal, as in Mr. Macintosh's experiment, iron is *gradually* brought to the state of steel, and then to that of cast iron. There is no precise limit between these three stages. At what period of the operation, and by what reaction, will the nitrogen previously absorbed again quit the iron? In malleable cast iron, whence comes the nitrogen if not contained in the cast iron itself? And in puddled steel, how can nitrogen combine with iron or carbon if cast iron does not contain it? I showed, in a paper on puddled steel, published a year ago in the *Annales des Mines*, vol. xv., that the fining of cast iron in a reverberatory furnace takes place under a coating of slag containing iron and manganese when puddled steel is to be obtained. I ask, then, how the hot atmospheric nitrogen of a furnace can combine with iron and carbon across this coating of scoria? Certainly, if puddled steel contains nitrogen, it can only proceed from cast iron, and it appears to me as interesting to prove its presence in cast iron as in steel itself. But let me be allowed to raise some doubts on the possibility of proving the presence of nitrogen in steel by hydrogen. At red heat, iron takes away the nitrogen from ammonia and sets the hydrogen at liberty; and at the same temperature will this hydrogen again take away the nitrogen from the iron,—from the iron which is always in excess relatively to the gaseous molecules which can react on it? It is more difficult to conceive the production of ammonia under these circumstances than the direct combination of hydrogen with free nitrogen.

Another fact which proves that steel and cast iron differ only in containing diverse proportions of the same elements is, that pure white cast irons can be tempered and even forged like steel; witness the white cast iron of Sieges, used for making screw-plates.

Finally, if forged natural steel contains nitrogen, this element ought also to be found in cast iron; and in the second place, it has long been proved that iron can be transformed at will, either into cast iron or steel, by ordinary or coal gas cementation. To effect either, a difference only of time and temperature suffices.—*Comptes-Rendus.*

Giffard's Injector.

From the Civ. Eng. and Arch. Jour., June, 1861.

The principle of Giffard's Injector appears to have been known upwards of a century ago. In 1753, Richard Savery of Birmingham, published a book in which he gave a plan and description of an apparatus for raising water by steam. A conical nozzle, discharging a

jet of steam, was shown within another similar nozzle, as in the Injector, the water being thus drawn up through and discharged from the annular passage. Among other copies of Savery's book, one is now preserved at Messrs. Elkington and Mason's of Birmingham.

Austrian Horse-Power.

From the Bulle. de la Soc. d'Encour. pour l'Indus. Nat.

The Austrian government has fixed the legal horse-power in that empire at 430 *pfunds* raised 1 *fuss* per second. This is equivalent to 76 kilogrammes raised 1 metre per second, or 32,982·85 lbs. raised 1 foot high per minute.—*Dingler's Polytech. Blatt.*

Report on Steam Boiler Explosions.

From the Lond. Mechanics' Magazine, June, 1861.

The monthly meeting of the executive committee was held on Tuesday, May 28, at the offices, 41 Corporation Street, Manchester; Hugh Mason, Esq., vice-president, in the chair. Mr. L. E. Fletcher, chief engineer, presented his monthly report, from which the following is extracted:—"During the month, we have made 195 visits, examined 501 boilers and 339 engines. The following are some of the principal defects which have been found to exist in the boilers inspected, and to which the attention of the owners has in each case been called:—Fracture, 14; corrosion, 16 (four dangerous); safety valves out of order, 21; water gauges ditto, 12; pressure gauges ditto, 8; feed apparatus ditto, 2; blow-off cocks ditto, 17 (one dangerous); fusible plugs ditto, 3; furnaces out of shape, 9 (two dangerous); over pressure, 1; deficiency of water, 1: total, 104 (seven dangerous). Boilers without glass water gauges, 65; ditto pressure gauges, 9; ditto blow-off cocks, 23; ditto feed back pressure valves, 76. After alluding to a case where a tubular boiler had been materially injured by incrustation, the report went on to state:—"I am so constantly meeting with cases of this sort, where, from the neglect of the simple precaution of blowing out, a good deal of property is sacrificed, that, even at the risk of repetition, I cannot forbear calling the attention of members to it. I am constantly asked what should be done to remove incrustation which should never have been allowed to form; and beg to recommend, as the most simple means for its prevention, regular blowing out from the surface when the water is in ebullition, and from the bottom when it is at rest. I find the blow-out apparatus in many boilers very inconvenient, if not entirely unfit for use, some of the taps being so made that they cannot be opened—or, if opened, cannot be closed; others being rammed full of horse dung till quite choked, to prevent leakage; while many have no waste pipes, so that the boilers can only be blown out when the pressure is low, for fear of scalding the men, and thus the practice is too frequently confined to the weak end. I would strongly urge upon our members the importance of depriving their engine-men of all excuse for neglect, by having the apparatus for blowing out, both from the surface of the water as well as from the bottom, put in complete working order, and

then let it be understood that further incrustation in their boilers is not to occur. This, I can assure them, would save them the trouble and expense incurred by many of constantly dosing their boilers with patent medicines. I may add, that perhaps as little trouble is experienced with a tap made with a close bottom, entirely of brass, and fitted with a gland, as with any other arrangement."—*Manchester Guardian.*

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 192.)

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 42{\cdot}8 \frac{D^{3{\cdot}76}}{L^2}$.	Safe weight in tons.
5	30	2	21·10		5·27
6	36	"		16·10	4·02
7	42	"		11·83	2·95
8	48	"		9·05	2·26
9	54	"		7·15	1·78
10	60	"		5·79	1·44
11	66	"		4·79	1·19
12	72	"		4·02	1·00
13	78	"		3·43	0·85
14	84	"		2·95	0·73
15	90	"		2·57	0 64
16	96	"		2·26	0·56
17	102	"		2·00	0·50
18	108	"		1·78	0 44
19	114	"		1·60	0·40
20	120	"		1·44	0·36
5	24	$2\frac{1}{2}$	42·34		10·58
6	28·8	"	33·58		8·39
7	33·6	"		27·34	6·83
8	38·4	"		20·93	5·23
9	43 2	"		16·54	4·13
10	48	"		13·39	3·34
11	52·8	"		11·07	2 76
12	57·6	"		9·30	2·32
13	62·4	"		7·92	1·98
14	67·2	"		6·83	1·70
15	72	"		5·95	1·48
16	76·8	"		5·23	1·30
17	81·6	"		4·63	1·15
18	86·4	"		4·13	1·03
19	91·2	"		3·71	0·92
20	96	"		3·34	0·83

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 42{\cdot}8 \frac{D^{3{\cdot}76}}{L^2}$.	Safe weight in tons.
5	20	3	72·88		18·22
6	24	"	59·45		14·86
7	28	"	48 83		12·20
8	32	"	40·47		10·11
9	36	"		32·88	8·22
10	40	"		26·63	6·65
11	44	"		22·01	5·50
12	48	"		18·49	4·62
13	52	"		15·75	3·93
14	56	"		13·58	3 39
15	60	"		11·83	2 95
16	64	"		10·40	2·60
17	68	"		9·21	2·30
18	72	"		8·22	2 05
19	76	"		7·37	1·84
20	80	"		6·65	1·66
5	17·142	3½	112·99		28·24
6	20·571	"	94·47		23·61
7	24	"	79·13		19·78
8	27·428	"	66·65		16·66
9	30·857	"	56·54		14·13
10	34·285	"		47·55	11·88
11	37·714	"		39·29	9·82
12	41·142	"		33·02	8 25
13	44·571	"		28·13	7·03
14	48	"		24·26	6·06
15	51·428	"		21·13	5·28
16	54·857	"		18·57	4·64
17	58·284	"		16·45	4·11
18	61·714	"		14·67	3·66
19	65 142	"		13·17	3·29
20	68 571	"		11·88	2·97
5	15	4	162·77		40·69
6	18	"	139·00		34·75
7	21	"	118 54		29·63
8	24	"	101·34		25·33
9	27	"	87·02		21·75
10	30	"	75·15		18·78
11	33	"		64·92	16 23
12	36	"		54·55	13·63
13	39	"		46·48	11·62
14	42	"		40·07	10·01
15	45	"		34·91	8·72
16	48	"		30·68	7·67
17	51	"		27·18	6·79
18	54	"		24·24	6·06
19	57	"		21·76	5·44
20	60	"		19·63	4·90

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 42{\cdot}8 \frac{D^{3{\cdot}76}}{L^2}$.	Safe weight in tons.
5	13 333	$4\frac{1}{2}$	222·17		55 54
6	16	"	193·21		48·30
7	18·666	"	167 43		41 85
8	21·333	"	145·08		36·27
9	24	"	125 98		31·48
10	26·666	"	109·72		27·43
11	29·333	"	96·27		24 06
12	32	"	84·94		21 23
13	34·666	"		72 38	18·09
14	37·333	"		62 41	15 60
15	40	"		54·36	13 59
16	42·666	"		47·78	11 94
17	45·333	"		42·32	10·58
18	48	"		37·75	9·43
19	50·666	"		33 88	8 47
20	53·333	"		30·58	7·64
5	12	5	291·07		72·76
6	14·4	"	257·10		64·27
7	16 8	"	225·94		56 48
8	19·2	"	198·22		49·55
9	21·6	"	174 02		43·50
10	24	"	153·12		38·28
11	26·4	"	135 20		33·80
12	28 8	"	119·80		29 95
13	31·2	"	106 64		26·66
14	33·6	"		92·74	23·18
15	36	"		80·79	20·19
16	38·4	"		71·01	17·75
17	40 8	"		62 90	15·72
18	43·2	"		56·10	14·02
19	45·6	"		50 35	12·58
20	48	"		45·44	11·36
5	10	6	456·78		114·19
6	12	"	413 58		103·39
7	14	"	372·00		93·00
8	16	"	333·14		83·28
9	18	"	298 21		74 55
10	20	"	266·78		66·69
11	22	"	238·95		59 73
12	24	"	214·45		53·61
13	26	"	192·95		48 23
14	28	"	174 09		43 52
15	30	"	157·56		39 39
16	32	"		140·95	35 23
17	34	"		124·86	31·21
18	36	"		111·37	27·84
19	38	"		99·95	24·98
20	40	"		90·21	22 55

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	30	2	1	36 85		30·28	7 57	3·02
6	36	"	"	44·22	22·58		5·64	2·25
7	42	"	"	51·59	17·37		4 34	1·73
8	48	"	"	58 96	13·85		3·46	1·38
9	54	"	"	66·33	11·33		2 83	1·13
10	60	"	"	73 70	9·47		2·36	0·94
11	66	"	"	81 07	8 06		2 01	0·80
12	72	"	"	88 44	6·95		1 73	0 69
13	78	"	"	95·81	6·06		1 51	0·60
14	84	"	"	103·18	5·34		1·33	0 53
15	90	"	"	110·55	4·75		1·18	0·47
16	96	"	"	117·92	4·26		1·06	0·42
17	102	"	"	125 29	3·84		0·96	0·38
18	108	"	"	132·66	3 48		0·87	0·34
19	114	"	"	140·03	3·18		0·79	0·31
20	120	"	"	147·40	2·91		0·72	0 29
5	20	3	2	61·42		82·51	20 62	8·25
6	24	"	"	73·71		68·32	17 08	6·83
7	28	"	"	85·99		57·26	14·31	5 72
8	32	"	"	98·28	48 73		12·18	4 87
9	36	"	"	110·56	39 88		9·97	3·98
10	40	"	"	122·85	33·34		8 33	3·33
11	44	"	"	135 13	28·35		7·08	2·83
12	48	"	"	147 42	24·45		6·11	2·44
13	52	"	"	159 70	21·34		5·33	2·13
14	56	"	"	171·99	18·81		4·70	1·88
15	60	"	"	184 27	16·73		4·18	1·67
16	64	"	"	196 56	14·99		3·74	1·49
17	68	"	"	208 84	13·49		3·37	1·34
18	72	"	"	221·13	12·27		3·06	1·22
19	76	"	"	233·41	11·20		2·80	1·12
20	80	"	"	245 70	10·26		2·56	1 02
5	15	4	3	85·99		149·60	37·40	14·96
6	18	"	"	103 19		128·79	32·19	12·87
7	21	"	"	120·39		111·37	27·84	11·13
8	24	"	"	136·59		96 88	24·22	9 68
9	27	"	"	154 79		84·84	21·21	8·48
10	30	"	"	171·99		74·79	18 69	7·47
11	33	"	"	189·18	66·04		16 51	6·60
12	36	"	"	206·38	56·96		14 24	5 69
13	39	"	"	223·58	49·71		12·42	4 97
14	42	"	"	240·78	43·83		10 95	4 38
15	45	"	"	257·98	38·98		9·74	3·89
16	48	"	"	275·18	34·93		8·73	3·49
17	51	"	"	292·38	31·50		7 87	3·15
18	54	"	"	309·58	28 59		7·14	2·85
19	57	"	"	326·78	26·01		6·50	2 60
20	60	"	"	343 98	23·90		5·97	2·39

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	12	5	4	110·56		224·13	56·03	22·41
6	14·4	"	"	132·67		198·66	49·66	19·86
7	16·8	"	"	154·79		176·16	44·04	17·61
8	19·2	"	"	176·90		156·55	39 13	15·65
9	21·6	"	"	199·01		139·59	34·89	13·95
10	24	"	"	221 13		124 96	31·24	12·49
11	26·4	"	"	243·24		112 33	28·08	11·23
12	28·8	"	"	265·35		101 41	25·35	10·14
13	31·2	"	"	287·46		91·93	22·98	9·19
14	33·6	"	"	309 58	82·75		20·68	8 27
15	36	"	"	331·69	73·59		18·39	7·35
16	38·4	"	"	353 80	65 95		16·48	6·59
17	40·8	"	"	375 92	59·49		14·87	5·94
18	43·2	"	"	398·03	53·98		13·49	5 39
19	45·6	"	"	420·14	49 24		12·31	4·92
20	48	"	"	442·26	45·12		11 28	4·51
5	10	6	5	135·13		302·25	75·56	30 22
6	12	"	"	162·16		273 80	68 45	27·38
7	14	"	"	189 18		247·60	61·90	24·76
8	16	"	"	216·21		223·91	55 97	22·39
9	18	"	"	243·24		202·74	50·68	20·27
10	20	"	"	270 27		183·94	45·98	18·39
11	22	"	"	297·29		167·29	41 82	16·72
12	24	"	"	324·32		152·58	38·14	15·25
13	26	"	"	351·35		139·57	34·89	13·95
14	28	"	"	378·37		128 04	32·01	12·80
15	30	"	"	405·40		117·82	29·45	11·78
16	32	"	"	432·43		108·72	27·18	10·87
17	34	"	"	459·45	98·97		24·74	9·89
18	36	"	"	486·48	89·81		22·45	8·98
19	38	"	"	513 51	81·92		20·48	8·19
20	40	"	"	540·54	75·08		18·77	7·50
8	$10\frac{2}{3}$	9	8	334·15		449·65	112·41	44·96
10	$13\frac{1}{3}$	"	"	417·69		392 96	98·24	39·29
12	16	"	"	501·22		343·17	85·79	34·31
14	$18\frac{2}{3}$	"	"	584·76		300·38	75 09	30·03
16	$21\frac{1}{3}$	"	"	668·30		263·99	65·99	26 39
18	24	"	"	751·84		233·16	58·29	23·31
20	$26\frac{2}{3}$	"	"	835·38		207·02	51·75	20·70
8	8	12	11	450·84		687·29	171·82	68·72
10	10	"	"	563·55		623·61	155·90	62·36
12	12	"	"	676·26		563·51	140 87	56·35
14	14	"	"	788·97		508·43	127·10	50 84
16	16	"	"	901·68		458·85	114·71	45·88
18	18	"	"	1014·39		414·71	103·67	41·47
20	20	"	"	1127·10		375·64	93 91	37·56

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34 \dfrac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \dfrac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	6 6-7	14	12½	781·33	1245·02	311·25	124 50
9	7 5-7	"	"	879·00	1195·69	298·92	119·56
10	8 4-7	"	"	976·67	1146·57	286·64	114·65
11	9 3-7	"	"	1074·33	1098·19	274·54	109·81
12	10 2-7	"	"	1172·00	1050·93	262·73	105·09
13	11 1-7	"	"	1269 67	1005·07	251·26	100·50
14	12	"	"	1367 33	960·82	240·25	96·08
15	12 6-7	"	"	1465·00	918 32	229·58	91·83
16	13 5 7	"	"	1562 67	877·64	219·41	87·76
17	14 4-7	"	"	1660·33	833·81	209·70	83·88
18	15 3-7	"	"	1758·00	801·87	200·46	80·18
19	16 2-7	"	"	1855 67	766·73	191·68	76·67
20	17 1-7	"	"	1953·34	733·40	183 35	73·34
21	18	"	"	2051·00	701·81	175·45	70·18
22	18 6-7	"	"	2148 67	671·88	167·97	67·18
23	19 5-7	"	"	2246·34	643 55	160·88	64·35
24	20 4-7	"	"	2344 00	616·75	154·18	61·67
25	21 3-7	"	"	2441·67	591·39	147·84	59·13
26	22 2-7	"	"	2539·34	567·39	141·84	56·73
27	23 1-7	"	"	2637·00	544·68	136 17	54·46
28	24	"	"	2734·67	523·20	130 80	52·32
29	24 6-7	"	"	2832·34	502·86	125·71	50·28
30	25 5-7	"	"	2930·01	483 59	120 89	48·35
8	6 2-5	15	13½	840·30	1366·04	341 51	136 60
9	7 1-5	"	"	945·34	1316·52	329·13	131·65
10	8	"	"	1050·38	1266·86	316·71	126·68
11	8 4-5	"	"	1155·41	1217·62	304·40	121·76
12	9 3-5	"	"	1260 45	1169·18	292 29	116·91
13	10 2-5	"	"	1365·49	1121·86	280·46	112·18
14	11 1-5	"	"	1470·43	1075·91	268·97	107·59
15	12	"	"	1575·47	1031·49	257·87	103·14
16	12 4-5	"	"	1680·60	988 72	247·18	98·87
17	13 3-5	"	"	1785·64	947·66	236 91	94·76
18	14 2-5	"	"	1890·68	908 38	227 09	90·83
19	15 1-5	"	"	1995·72	870·82	217·70	87·08
20	16	"	"	2100·76	835·00	208·75	83·50
21	16 4-5	"	"	2205·79	800·90	200·22	80·09
22	17 3-5	"	"	2310·83	768·44	192·11	76·84
23	18 2-5	"	"	2415·87	737·59	184·39	73·75
24	19 1-5	"	"	2520·91	708·28	177·07	70·82
25	20	"	"	2625·95	680·44	170·11	68·04
26	20 4-5	"	"	2730 98	653·99	163·49	65·39
27	21 3-5	"	"	2836·02	628·87	157·21	62·88
28	22 2-5	"	"	2941·06	605 05	151 26	60·50
29	23 1-5	"	"	3046·10	582·41	145 60	58·24
30	24	"	"	3151·14	560·91	140·22	56 09

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	6	16	14½	899·27	1487·02	371·75	148 70
9	6 3-4	"	"	1011·68	1437·50	359 37	143·75
10	7 1-2	"	"	1124·09	1387·54	346·88	138·75
12	9	"	"	1348 90	1288 34	322·08	128·83
15	11 1-4	"	"	1686·13	1146·46	286 61	114·64
20	15	"	"	2248·18	939·67	234·91	93·96
8	5 11-17	17	15½	958·24	1607 94	401·98	160 79
10	7 1-17	"	"	1197 80	1508·47	377·11	150 84
12	8 8-17	"	"	1437·36	1408·20	352·05	140·82
15	10 10-17	"	"	1796·70	1262·90	315·72	126·29
20	14 2-17	"	"	2395·60	1047·01	261·75	104·70
8	5 1-3	18	16½	1017·20	1728·69	432·17	172·86
10	6 2-3	"	"	1271·50	1629·46	407·36	162·94
12	8	"	"	1525·80	1528·49	382·12	152·84
15	10	"	"	1907·25	1380·42	345·10	138·04
20	13 1-3	"	"	2543·00	1156 53	289·13	115·65
10	5 15-21	21	19	1965·50	2616·54	654·13	261·65
15	8 12-21	"	"	2948·25	2277 34	569·33	227·73
20	11 9-21	"	"	3931·00	1956·15	489·03	195·61
10	5	24	22	2260·20	3099·32	774 83	309·93
15	7 1-2	"	"	3390·30	2758·42	689·60	275·84
20	10	"	"	4520·40	2421·21	605 30	242·12

Having brought this series to a conclusion, I purpose in a succeeding series giving the strength of timber pillars.

On the Preparation of Artificial Coloring Matters with the Products Extracted from Coal Tar. By M. E. Kopp.

From the Lond. Chemical News, Nos. 40 and 42.

(Continued from page 184.)

Before rectification the oils are agitated for an hour with concentrated sulphuric acid, the light with 5 and the heavy with 10 per cent. They are then allowed to rest for 24 or 36 hours, for the acid and impurities to deposit. The oil is then separated and washed once or twice with water, and afterwards with a solution of caustic soda sp. gr. 1·382. For the lighter, 2 per cent. of the soda solution will be enough, but the heavier will require 6 per cent. When so purified, the light oil is rectified by distillation with a current of steam. The condensed product, having a mean density of ·815 to ·820, is the benzole of commerce.

The heavy oil is distilled without the assistance of a current of steam. The condensed product has a mean density of ·860, is of a

clear yellowish color, similar to that of Madeira wine, and has the disagreeable odor of sulphur compounds, formed by the action of the sulphuric acid. This may be destroyed by shaking the oil before distillation with a solution of sulphate of iron, or after distillation with the addition of some caustic soda to the sulphate of iron. A blackish deposit of sulphide of iron is formed and the oil loses its bad odor.

Paraffine and the heavier mineral oils which drain from the paraffine are purified in the same way by means of sulphuric acid, which is sometimes combined with oxidizing agents, such as bichromate of potash, peroxide of manganese, manganate of potash, &c., and subsequent washing with caustic soda. After the action of the acid and alkali, paraffine is sometimes rectified by a second distillation, but more frequently the purification is completed by a second treatment with sulphuric acid, followed by a careful washing, after which the paraffine is mixed with 1 per cent. of stearic acid, and treated with the caustic soda. The alkali by saponifying the stearic acid forms soapy flocculi, which envelope the impurities, and the melted paraffine is rendered perfectly limpid.

The acid and alkaline residues of the above purifying processes are generally thrown away, but in them are found the principles which may be utilized for the production of the coloring matters. The sulphuric acid, for example, must combine with all the alkaline compounds, such as aniline, quinoline, toluidine, cumidine, &c.; while the caustic soda must unite with the acid principles, like phenol, creosote, and rosolic acid. Vohl* has already proposed to extract phenol and creosote from the alkaline solution by supersaturating it with the acid solution, decanting the oily layer which separates, and rectifying it over a naked fire. A more rational process, according to the author, would be the following:—Collect all the acid and alkaline liquors, and determine how much of the acid liquor would be sufficient to saturate a given volume of the alkaline. This being known, mix the alkaline solution with twice the quantity of acid liquor necessary to saturate it. If the two be mixed rapidly, sufficient heat will be developed to raise the mixture almost to the boiling-point, and a concentrated solution of bisulphate of soda will be formed, which retains in solution the bisulphates of aniline and toluidine, while the phenol and creosote easily separate in form of a brown oil. This oil may be separated while the mixture is still warm, and rectified. A light neutral oil first passes, and afterwards the phenol and creosote distil almost pure.

The solution containing the acid sulphates of soda and the organic bases yields on cooling crystals of bisulphate of soda, which may be collected on a filter. The acid liquor not used to saturate the soda solution may then be added from the mother-liquor from the crystals, and the whole heated to 60° or 80° C. Chalk or milk of lime is then added to partial saturation, the sulphate of lime is allowed to deposit, and the liquor is concentrated. Finally, the concentrated acid sulphates are introduced into an iron still, and an excess of quicklime is added. Sulphate of lime and some sulphate of soda are formed, the

* *Journal fur Prakt. Chem.* Bd. lxxv. s. 295.

organic bases are set at liberty, and on heating they pass over and condense with some water. If the quantity of water be sufficient to hold the bases in solution, the distilled aqueous solution must be saturated with hydrochloric acid and evaporated, first over a naked fire and then over a water bath, almost to dryness. The residue placed in a retort is mixed with an excess of quicklime and distilled, when an oily liquid is obtained, which consists principally of aniline, toluidine, and quinoline, sufficiently pure for the preparation of the coloring matters.

We shall now notice successively the compounds from which the coloring matters may be formed, and the coloring matters themselves, describing the most advantageous and best known process for obtaining them.

1. *Aniline.*—Unverdorben first discovered aniline among the products of the dry distillation of indigo in 1826. As it formed crystallized salts with acids, he gave it the name of *crystalline.* In 1840, Fritsche made anthranilic acid by introducing finely powdered indigo into a hot and strongly concentrated solution of caustic potash. One of the most remarkable properties of this acid is its splitting up into carbonic acid and aniline when distilled with quicklime.

$$\underbrace{C_{14}H_7NO_4}_{\text{Anthranilic Acid.}} + 2\,CaO = \underbrace{C_{12}H_7N}_{\text{Aniline.}} + 2\,(CO_2.CaO).$$

Erdmann first observed that aniline was identical with the crystalline of Unverdorben. Hoffmann afterwards showed that to prepare aniline it was not necessary to make anthranilic acid, but that it sufficed to distil indigo directly with hydrated caustic potash, the aniline being formed in consequence of a real oxidation of the indigo.

Isatine, a product of the oxidation of indigo by weak nitric acid, also furnishes aniline on distillation with caustic potash. Runge, 1837, first announced the existence of three volatile bases in coal tar, which he named respectively kyanol, leukol, and pyrrol. Hoffmann subsequently demonstrated that kyanol was identical with aniline, and later he proved that leukol was identical with quinoline, a base which Gerhardt had obtained by distilling the cinchona alkaloids with mineral alkalies. Another very remarkable method of forming aniline is based upon the action of reducing bodies on nitro-benzole. Zinin, by saturating an alcoholic solution of nitro-benzole with ammonia, and then passing sulphuretted hydrogen as long as any deposit of sulphur was formed, obtained an organic alkali which he called benzidam, but which was afterwards proved to be aniline.

$$\underbrace{C_{12}H_5NO_4}_{\text{Nitrobenzole.}} + 6\,HS = C_{12}H_7N + 4\,HO + 6\,S.$$

Bechamp showed that the reduction could be effected equally well by means of ferrous acetate or acetic acid and iron.

$$C_{12}H_5NO_4 + 6\,Fe + H_2O_2 + 6\,\bar{A} = C_{12}H_7N + 6\,(FeO\bar{A}).$$

Before this, however, Hoffmann had shown that nitro-benzole might be converted into aniline by the action of zinc and hydrochloric acid.

Lastly, Wöhler has discovered that nitro-benzole may be reduced and transformed into aniline by digestion and distillation with a solution of arsenious acid in an excess of caustic soda.

Amongst other methods of producing aniline we quote the following: Phenol and ammonia placed in a stout tube sealed and exposed for a long time to a high temperature from aniline.

$$\underbrace{C_{12}H_6O_2}_{\text{Phenol.}} + NH_3 = C_{12}H_7N + 2HO.$$

According to Hoffmann and Muspratt, nitro-toluene and salicyalimide, two bodies isomeric with anthranilic acid, furnish aniline when heated to redness.

$$\underbrace{C_{14}H_7NO_4}_{\text{Nitrotoluene.}} = C_{12}H_7N + 2CO_2.$$

Of all the methods, however, two only appear to serve as industrial processes:

1. Extraction from coal tar.
2. Reduction of nitro-benzole.

Extraction of Aniline from Coal Tar.—The method which appears to be the most rational, and which deserves to be tried, would consist in treating the tar as condensed in gas works, with hydrochloric or sulphuric acid, diluted with 3 or 4 times its volume of water. Mechanical means for effecting the intimate mixture of the tar with the acid might be easily contrived, but in the absence of any special contrivance, the end may be attained by half filling a barrel with the tar, adding one-fifth or one-sixth its volume of acid, and rolling and shaking the barrel until the acid has taken up all the bodies with which it is able to combine; the whole might then be run into a cistern, where by degrees the watery liquid would separate from the tar. The same acid liquid might be used over and over again, until the bases had nearly saturated the acid. A very impure aqueous solution would thus be obtained, but containing the hydrochlorates or sulphates of ammonia, and all the other organic bases contained in the tar, such as aniline, quinoline, pyrrol, picoline, pyrrhidine, lutidine, toluidine, cumidine, &c. By evaporating this solution almost to dryness, and then distilling with an excess of milk of lime, the bases would be set at liberty. Ammonia, as the most volatile, would be disengaged first, and might be condensed apart, and by raising the temperature higher and higher the other bases would be disengaged. Aniline would be found among the liquids distilling between 150° and 250° C.

The manipulation of the tar, however, is an extremely disagreeable operation, and presents many difficulties; it is therefore preferable, in most cases, to distil the tar first, and only operate on the most pure and limpid distilled oils.

Aniline, because of its high boiling-point, is never met with in the light and volatile liquids which first distil from tar. The most of it is found in those which distil between 150° and 230° C. These, according to Hoffmann, contain about 10 per cent. of organic bases, mostly

aniline and quinoline. The oils which distil above 250° contain mostly quinoline, and very little aniline.

The following is Hoffman's process for extracting the two bases from the oils and separating them. The oil is agitated strongly with commercial hydrochloric acid. The mixture is then allowed to rest for 12 or 14 hours, and the oil is separated from the acid; the latter is treated again with fresh quantities of oil until it is nearly saturated. The still acid solution of the hydrochlorates is filtered through linen or wetted filtering paper, to retain the greater part of the oil mechanically mixed with the watery solution; it is then placed in a copper still, and supersaturated with an excess of milk of lime. At the moment of saturation an abundance of vapors are given off, and the head must be quickly fixed on the still. Heat is now applied, so as to obtain a quick and regular ebullition.

The condensed product is a milky liquid, with oily drops floating on it. The distillation is carried on as long as the vapor has the peculiar odor of the first part distilled, or the condensed product gives the characteristic reaction of aniline with chloride of lime.

The milky liquid is now saturated with hydrochloric acid; it is then concentrated in a water bath; and lastly, decomposed in a tall narrow vessel by means of a slight excess of hydrate of potash or soda. The bases set free, unite, and form an oily liquid, which floats on the alkaline solution. This is removed with a pipette and rectified. The rectified product is aniline, sufficiently pure for industrial purposes, especially if we set aside the part distilling above 200° or 220°, which is principally composed of quinoline.

To obtain aniline chemically pure, the neutral oils forming part of the oily layer must be completely removed. This is done by dissolving the whole in ether, and adding dilute hydrochloric or sulphuric acid, which combines with and separates the bases, and leaves the oils in solution in the ether. The acid solution is then decanted, decomposed with potash, and submitted to careful fractional distillation. If the products are gathered separately in three parts, the first will contain ammonia, water, and some aniline; the second will be pure aniline; while the third portion will contain mostly quinoline. An alcoholic solution of oxalate acid is now added to the impure aniline, which precipitates oxalate of aniline, as a mass of white crystals, which are washed with alcohol, and then pressed. The salt is then dissolved in a small quantity of water, to which a little alcohol is added. From this solution the oxalate crystallizes in stellated groups of oblique rhomboidal prisms. These crystals are decomposed by a caustic alkali, to set free the aniline, and when this is distilled, water at first passes, then water charged with aniline, and lastly, at 182° C. chemically pure aniline.

Artificial preparation of Aniline by the reduction of Nitro-benzole.—This process, which constitutes one of the most curious and important reactions of organic chemistry, allows us to obtain aniline in any quantity. It is not difficult to prepare, but certain precautions are necessary when operating on a large scale.

The process may be subdivided into three distinct operations.

1. *Preparation of Benzole.*
2. *Transformation into Nitro-benzole.*
3. *Reduction of Nitro-benzole to form Aniline.*

1. *Preparation of Benzole.*—The only process we have space to notice is that by which benzole is obtained on a large scale, viz: the extraction from coal-tar, or from the first products of the distillation of coal-tar, light oil, or crude naphtha.

The manufacturer who wishes to distil tar in order to procure the largest amount of benzole, should choose a light fluid tar, and preferably one distilled from boghead or cannel coal. To form a comparative estimate of the value of different tars, the following experiment may be performed:—About 20 pints of the tar are distilled until the vapors, instead of condensing into a liquid, furnish a product which, on cooling, becomes solid, or of a buttery consistence. By carefully observing when the condensed oil becomes heavier than the water, and measuring the volume of the lighter oils which float on the surface of the water, and then comparing the volumes, we are enabled to estimate with tolerable accuracy the value of the tar. Of course, that which yields the largest amount of light oil is the best.

Some account of the process of distillation was given at pages 124 and 148 of this volume, to which we refer the reader, and also to the paper by Mr. Mansfield, in the *Quarterly Journal of the Chemical Society*, i. p. 244.

Crude naphtha, or the benzole of commerce, is generally a yellow or brown liquid, having a density varying from ·90 to ·95; it usually contains, besides benzole, some of the homologues of benzole, toluol, cumol, and cymol. It is impossible to separate these bodies by an ordinary process of rectification; for although the boiling point of toluol is 108° or 109°, and that of cumol 143° or 145°, their vapors are, so to say, dissolved in the vapor of benzole, and are carried over and condense together. Their presence, however, need not interfere with the preparation of nitro-benzole and aniline.

The benzole found in commerce is at times very impure; some, indeed, has been met with containing but a trace of real benzole. Such an article is generally the result of the distillation of bituminous schists or asphaltum; and, besides hydrocarbons belonging to another series than that of benzole, it generally contains a small amount of oxygenated products, and consequently cannot be advantageously used in the preparation of aniline. It is therefore important to be able readily to detect benzole in a mixture of other oils. For this purpose we may avail ourselves of the facility with which true benzole is converted into nitro-benzole and then into aniline by the action of nascent hydrogen.

The following is Hoffmann's method:—A drop of benzole is heated in a small test-tube, with fuming nitric acid, to convert it into nitro-benzole. A good deal of water is then added, to precipitate the nitro-benzole in small drops, which must be taken up by ether. The etherial solution is then poured into another small tube, and equal volumes of

alcohol and dilute hydrochloric acid are added; a few fragments of granulated zinc are then dropped in. In about five minutes sufficient hydrogen will have been disengaged to produce aniline, which will be found combined with the acid. The liquid is supersaturated with an alkali and shaken with ether, which dissolves the aniline set free. A drop of this etherial solution allowed to evaporate on a watch glass, and mixed after the evaporation of the ether with a drop of a solution of hypochlorite of lime, will show the violet tints which characterize aniline. The operations may be executed very rapidly, and without any difficulty.

Properties of Benzole.—At the ordinary temperature benzole is seen in the form of a colorless very fluid liquid, of an agreeable(?) odor, and having the specific gravity ·85° at 15° C. At a very low temperature it crystallizes or forms a mass like camphor, which melts at 5°. Its boiling-point is between 80° and 81°, and it distils without undergoing any change. It is nearly insoluble in water, to which, however, it imparts its peculiar odor; it is very soluble in wood-spirit, ether, alcohol, the essential and the fatty oils; and it easily dissolves camphor, wax, fatty matters, india-rubber, gutta-percha, and a great number of resins. Among the last, those which are least soluble in it are shellac, copal, and animi. It is very inflammable, and burns with a brilliant smoky flame. Hydrogen gas passed through it, and charged with its vapor, burns with a very clear, luminous flame.

Chlorine and bromine convert benzole into the terchloride and terbromide of benzole. In direct solar light the change takes place very quickly. Concentrated sulphuric acid dissolves benzole, and when the mixture is gently heated, a copulated acid, sulpho-benzylic acid is formed, $C_{12}H_6S_2O_6$, the hydrogen of which may be replaced by metals. As this acid is soluble in water, we see that in purifying rough benzole with sulphuric acid it is necessary to avoid using an excess of the acid, and also heating the mixture. A solution of chromic acid does not act on benzole, and is therefore a good agent for the purification. Concentrated nitric acid converts benzole into nitro-benzole, to the manufacture of which we next proceed.

(To be Continued.)

Specification of a Patent granted to William Prosser *and* Henry John Standly, *for Improvements in Apparatus employed in the production of Light.*—Dated 25th October, 1860.

From Newton's London Journal, July, 1861.

These improvements are applicable where oxygen and hydrogen gases, or their compounds, are employed to produce light by their ignition on a surface of lime or other suitable material; and the improvements relate to the use of two or more pieces of lime or other material abutting against each other and pressed in opposite directions towards the jet or jets of flame which impinge upon them,—the one being used as an abutment for the other. When more than two pieces of lime or other material are used, they should be caused to converge or other-

wise move towards a common centre, each piece being pressed forward by a spring or weight, or other convenient means, so as to keep the pieces of lime or other material in contact with each other at or about the place where the jet or jets of flame impinge upon them; and these pieces of lime or other material are placed in tubes, cases, or holders, and advanced so as to cause the pieces of lime to move towards each other as they are consumed or dissipated by the action of the jet or jets of flame, and thus they are kept in contact at or about the place where the jet or jets of flame strike.

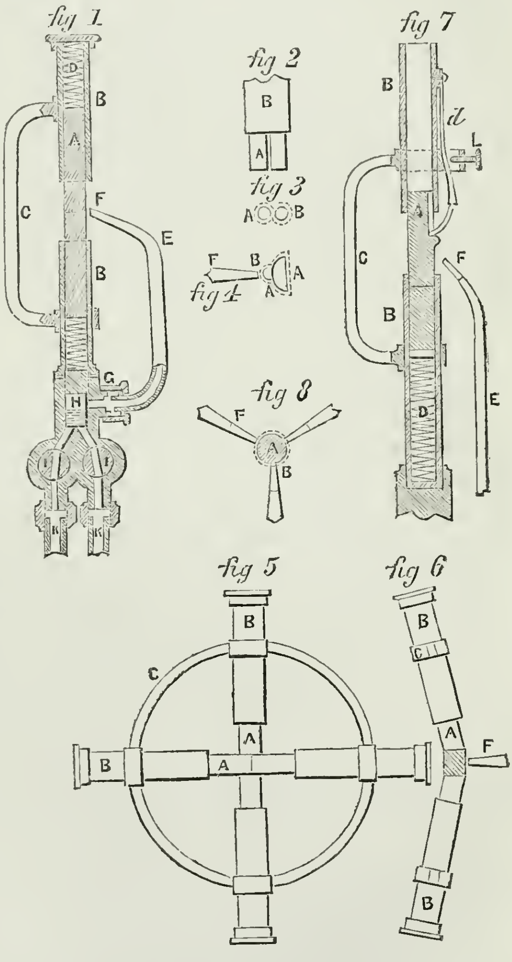


Figure 1 shows, in vertical section, an arrangement for using two pieces of lime (that material being preferred) either in the same line, or angularly with respect to each other. The pieces of lime are pressed towards each other by springs, which prevent them from being dislodged from the holders. Figs. 2, 3, and 4 show arrangements in which the lime is similarly moved forward by springs, the pieces of lime being of various forms of section.

Figs. 5 and 6 show an arrangement by which several pieces of lime may be disposed round a jet, either in a flat plane or angularly to each other, and converging towards the jet.

Fig. 7 shows a modification of the foregoing, in which the resistance to the undue advance of the piece or pieces of lime is effected by the pressure of a spring acting against the surface of the lime, instead of against the end of an opposing piece of lime; the object sought to be obtained, in all cases, being to prevent the lime being moved otherwise than as it is consumed.

Fig. 8 is a transverse section of a piece or pieces of lime, with several jets disposed round it, so as to illuminate the entire space surrounding the lamp.

In applying these lamps to various purposes, the vertical or horizontal arrangement will be adopted, as may be best suited to the object; as, for instance, when a lamp is required to illuminate the space in front of it, the vertical arrangement is the most convenient, and when the space beneath the lamp is required to be illuminated, the horizontal arrangement is preferable. Fig. 7, with a single jet, is a very convenient form of lamp for illuminating the space in front of it; and when three or more jets are used, as at fig. 8, it is applicable when required to illuminate a large space around it.

A, is the lime upon which the jet of flame is made to impinge. When the lime is used horizontally, the jet will be more conveniently applied at right angles to the lime; and when used vertically, it will be found more convenient to apply the jet inclined to the lime (as in fig. 1). B, are metal holders, made to suit the sectional form of the lime. The ends of the holders are furnished with caps, for the convenience of inserting the pieces of lime (and their springs) when the lamp requires replenishing. The holders are connected together by a bar or frame, C. D, are springs, which press upon the pieces of lime, and cause their movement as they are consumed.

In figs. 1 and 5, the movement of the lower piece of lime is prevented by the pressure of the upper piece, until that portion which is opposite to the jet is consumed; and in fig. 7, a spring, *d*, is substituted for the upper piece of lime and its spring. The point of the spring, *d*, is terminated by a piece of iridium or other material capable of withstanding the heat to which the lime is subjected, without melting. E, is a jet having a nipple, F, at its extremity, from which the combined gases issue and impinge against the lime; it is connected by an union cap, G, to a chamber, H, into which the gases are introduced and there mixed before issuing from the jet; I, I, are regulating cocks (one for each gas), through which the gases pass to the chamber, H; and K, K, are pipes leading from the gas holders to the cocks, I, I. It will be obvious that the advance of the lime can only take place when the abutting points are in a state of fusion: where the pieces of lime are caused to abut against each other, and where the jet of flame is caused to act upon the point of junction of the pieces of lime, the fusion will take place at that point, and thus the lime, being in a soft or plastic state, will be pressed together by the springs, D.

In fig. 7, the same effect takes place: the lime, being fused by the jet or flame, is rendered plastic at the place where the point of the spring, *d*, presses upon it and becomes embedded in it. The lime is thus permitted gradually to advance to or before the jet of flame.

It will be obvious that unless a progressive movement be given to the lime, the light will gradually lose its brilliancy as the space between the point of the jet and the surface of the lime becomes increased. A chamber, H, is provided between the regulating cocks and the jet, in which from twelve to twenty wire gauze washers are placed,

through which the gases pass and become thoroughly mixed, and through which the regurgitation of the flame is effectually prevented.

The patentees claim, "the arrangement, as herein described, of the pieces of lime or other material, and the mode of regulating their movement as they are consumed and rendered unfit for the purpose of producing a uniform and brilliant light, by the ignition of oxygen and hydrogen gases or their compounds thereon."

New Maximum Thermometer.

This instrument, contrived by M. Doulcet and constructed by M. Baudin, is nothing more than the ordinary minimum alcohol thermometer; except that the glass index has but one bulb in place of two, and terminates in a point at its outer end. When this instrument is hung vertically with the bulb uppermost, the index falls until the point touches the lower edge of the liquid: here it stops; now, if the liquid expands, the index will fall farther, but, if it contracts, the adhesion is not sufficient to lift the index, which remains in its place. It is said even to be very firm, so that severe jars will not displace it, and the best method of re-adjusting the instrument, is to warm the bulb until the liquid again reaches the point; the index is then easily moveable.—*Cosmos.*

On the Composition of Cast Iron and Steel. By M. E. Fremy.

From the London Chemical News, No. 77.

The phenomena determining the production of steel have always occupied the attention of chemists and manufacturers, but at the present moment the study of this question has assumed an exceptional importance. In fact, the construction of machines and the manufacture of fire-arms are extending the applications of steel, and necessitate its production as economically as possible, consistently with preserving its valuable properties. To resolve this problem, of so much interest to metallurgical industry, chemistry ought to throw fresh light on the theoretical questions relating to the production of steel, and to free manufacture from the uncertainty and empirical methods which retard its due development.

The theories hitherto proposed to explain the phenomena of steeling, are evidently inadequate to guide the metallurgist wishing to produce steel either by the cementation of iron by charcoal or by decarburetting cast iron by special puddling.

Thus, the influence of manganese and that of tungsten in the process of steeling is not easily explained. The utility of nitrogenized organic substances and certain saline matters in aiding solution, is denied by experienced metallurgists. Some are of opinion that the best quality of cemented steel is obtained by the action of carbon on pure iron; others, that cementation can take place only under the influence of the nitrogen of the air. In either case, theory does not tell us why certain irons yield the best steel, while others, to all appear-

ance as pure, produce a very inferior quality. It is well known that the difficulties in the fabrication of steel obtained by puddling are such as often to discourage the most skilful manufacturers.

This uncertainty in the methods of steeling is found likewise in the theories proposed for explaining the production of steel. Some chemists are of opinion that solid carbon acts directly on iron, penetrates the metal, and circulating in its mass, converts it into steel. Others, among whom Leplay and Laurent are conspicuous, believe that cementation is invariably owing to the action of a gaseous carburetted compound of iron. Laurent goes so far even as to say that in the cementation boxes the vapor of the volatilized carbon effects the acieration.

The action exercised on iron by cyanides widens the field of the theory of cementation. A familiar experiment in chemistry has been utilized in practice: it consists in converting iron into steel by heating it with an alkaline cyanide or ferrocyanide. And, again, M. Caron, in a recent and interesting communication to the Academy, states that cyanide of ammonium, which is formed in the cementation-boxes, acts on iron like alkaline cyanides and rapidly converts it into steel.

The papers published on the subject of acieration have, doubtless, enriched science with many new and important facts; above all, they have particularized the circumstances which appear to determine this process most readily, but they have thrown no new light on the theoretical questions relating to the chemical constitution of steel. The writers still aver that steel is a carburet of iron, which they place chemically between iron and cast iron.

My opinion as to the composition of steel differs entirely from those hitherto accepted. I hope to be able to prove that steel is not a carburet of iron, and that there exists a series of steels resulting from the combination of iron with metalloids, metals, and even with cyanuretted bodies.

I am not acquainted with a single unequivocal experiment tending to show that steel is a combination of pure carbon and iron. Minute proportions of foreign bodies, not always detectable by analysis, can modify the properties of iron. When it is proposed to study the action of pure carbon on iron, there are necessarily other bodies present besides those whose mutual action we desire to determine. Without referring to the impurities taken up from the crucible, there are the influence of the gases from the furnace, which penetrate the apparatus; the action of the atmospheric elements which the charcoal does not absorb; or the presence of the various substances contained in the charcoal itself,—all of which circumstances are wholly disregarded.

In an experiment with diamond-dust, which I shall presently state, the influence of foreign bodies have been equally unheeded.

I shall now recal the fact I have already submitted to the Academy, which is, that steel, when dissolved in acids, leaves a residue in no point resembling pure carbon, and which, by its properties and composition, is nearly allied to certain carburetted products; thus, both

synthetical and analytical experiments are far from proving that steel contains nothing but carbon and iron.

To determine the true constitution of steel, and to ascertain whether there does not exist a series of bodies differing in composition, as tungsten steel differs from that of charcoal, yet allied by certain common properties, I propose to submit iron to the action of all the bodies capable of influencing the phenomenon of acieration.

I think that nitrogen ought to take the first place in this examination. Such was the object of my last communication to the Academy.*

I have applied myself to free nitride of iron from the excess of metal it is capable of retaining, and to produce, as far as possible, a definite compound.

But in the nitration of iron, as in the carburation of this metal, there are different degrees. Before forming under the influence of nitrogen, the scales which come off, and which, according to my experiments, contain 9·5 per cent. of nitrogen, the general properties of the metal undergo profound modifications; while preserving a certain malleability, it becomes white and fibrous. The iron in this state is still metallic, but, nevertheless, is strongly nitrogenized. It is this nitrogenized iron which I submit to the Academy, and which has undergone the processes connected with steeling which I am about to describe.

Desiring to study the successive or simultaneous action of nitrogen and carbon on iron, I was first obliged to find out a simple and easily graduated method of carburation as certain as the process for the nitration of iron by ammonia.

The action of illuminating gas on iron possesses all these advantages. In fact, I have proved that if dry coal-gas is passed at red heat during two hours on iron, I obtain a very regular carburation, and the metal is converted into a grey cast iron, graphitic, very malleable, and in every way comparable to the best cast iron produced by wood charcoal. I present to the Academy a specimen of cast iron formed under these circumstances.

By employing ammonia and coal-gas, I possess two easily regulated processes, which enable me to study, either isolatedly or simultaneously, the action of ammonia and carbon on iron.

The result of my experiments is, that when iron is submitted to the action of coal-gas I obtain cast iron only; but when the carburetted gas is made to react on previously nitrogenized iron, the characteristics of steel are evident in the metallic compound. A very remarkable fact here appears, which is, that the properties of the steel in some measure depend on the quantity of nitrogen first imparted to the iron. If the nitration has not been carried on a sufficient time, the coal-gas, in acting upon iron, produces a body intermediate between steel and cast iron; if, on the contrary, the metal has undergone a sufficient degree of nitration, the gas produces a steel of magnificent grain. The specimens which I presented to the Academy were formed in this manner. I have thus been enabled to realize M. Despretz's anticipations, and to determine what influence nitride of iron exercises on the phenomena of steeling.

* Chemical News, Vol. iii. p. 276.

When, instead of making nitrogen and carbon react successively on the metal, I have passed a mixture of ammonia and lighting-gas on red-hot iron, the metal has immediately changed to steel, which varies with the relative proportions of the two gases.

In the experiments here described, I believe I have for the first time produced steel by means of the successive action of two gases on iron—one, ammoniacal gas, furnishing nitrogen; the other, lighting-gas, furnishing carbon; and what appears to me to make the steel thus obtained still more interesting is, that with it cementation is no longer effected with wood charcoal, but with coal-gas. I ask metallurgists whether these experiments, which, in a theoretical point of view, throw light on the phenomenon of cementation, will not one day be practically utilized. Would it not be a curious circumstance in the cementation of iron were wood charcoal superseded by the products of the distillation of coal?

These facts establish positively the important part nitrogen plays in the phenomena of steeling. It remained for me to ascertain whether nitrogen, evidently a cementing agent, remains in the metallic compound, or whether its only use is to present carbon to the iron in a state favorable to chemical combination.

To resolve this interesting question, I submitted steel, obtained with ammonia and lighting gas, to the influence of the agent which could prove the presence of nitrogen in steel with the greatest nicety, viz: pure and dry hydrogen.

By heating in hydrogen some steel prepared in my laboratory, I immediately detected the presence of nitrogen in this metallic compound; for during the whole of the experiment it disengaged considerable quantities of ammonia.

After thus re-finding nitrogen in steel obtained by the action of ammonia and lighting-gas on iron, it became interesting to submit ordinary steel to the same proofs, and to ascertain whether these metallic compounds are equally nitrogenized.

To this end I have operated on steels of various sorts, all in high commercial estimation. My experiments were made successively on Jackson's French, Huntsmann's English, and Krupp's German steel.

(To be Continued.)

On the Amounts of Lead contained in some Silver Coins. By Messrs. Charles W. Eliot and Frank H. Storer.

From the London Chemical News, No. 77.

From our experiments upon the impurities of commercial zinc,* we found that this metal almost invariably contains lead. In the preparation of silver at the United States Mint, zinc is used for the purpose of reducing chloride of silver,† and a sample of zinc similar to that

*Memoirs of the American Academy, 1860 [N. S.], viii. 57.

†Booth and Morfit's Smithsonian Report on Recent Improvements in the Chemical Arts. (Washington, 1851.) p. 56. Compare Wilson's Report on the New York Industrial Exhibition, in *Lingler's Polyt. Journal*, 1855, cxxxv. 119.

used at the Mint, which we examined, yielded half of one per cent. of lead. The question naturally suggested itself whether lead might not thus find its way into American silver coin, and to determine this point, we have analyzed several American coins, as specified in the following table. For the sake of comparison, we subsequently examined the other coins therein enumerated.

(1) Kind of Coin.	(2) Weight of Coin taken.	(3) Weight of BaO, SO_3 found.	(4) Weight of Pb corresponding to SO_3 in the BaO, SO_3 of column (3).	(5) Corresponding per cent. of Lead in the Coin.	(a)* Weight of PbO, SO_3 found.	(b)* Corresponding weight of Pb.	(c)* Corresponding per cent. of Lead in the Coin.
	Grms.	Grms.			Grms.		
1 American half-dollar of 1824,	13·2936	0·0165	0 0412	0·3100	0·0480	0·0327	0·2462
20 American five-cent pieces of 1853,	24·2630	0·0571	0·0507	0·2090	0·0555	0·0379	0·1560
10 American five-cent pieces of 1854,	12·1980	0·0314	0·0278	0·2282	0·0270	0·0185	0·1513
2 American twenty-five cent pieces of 1858,	12·4097	0·0322	0·0286	0·2305	0·0310	0·0273	0·2200
"Fine silver,"† from the U. S. Assay Office in New York, 1860,	30·6405	0·0557	0 0494	0·1611	0·0655	0·0447	0·1457
1 Spanish dollar of 1793, Carolus IV.,	27·0130	0·0170	0·0151	0·0558	0 0129	0·0088	0·0326
1 Mexican dollar of 1829,	27·2265	0·0127	0·0118	0·0434	—	—	—
2 English shillings of 1816,	10·4597	0·0537	0·0507	0·4847	0·0590	0·0422	0·3846
1 French five-franc piece of 1852, Napoleon III.,	24 9725	0·1135	0·1069	0 4282	0·1296	0·0886	0·3546

On the supposition that the zinc used in the reduction of the silver is the source of the lead in the American coin, it is easy to calculate the amount of lead which would thus find its way into the coin, since the quantity of zinc used in reducing a given weight of silver, and the per cent. of lead which that zinc may be expected to contain, are both known quantities. Professor Booth‡ says that an excess of zinc is required to insure total and rapid reduction, and Wilson§ states that two equivalents of zinc are used, in practice, for each equivalent

*Columns (a), (b), and (c), contain the results of a supplementary series of experiments, made merely to control the results given in columns (4) and (5). (*Vid. infra.*)

†The solution of this fine silver in nitric acid became blue when neutralized with ammonia. The filtrate from the mixed precipitate of sulphate of lead and gold contained a decided trace of copper and a fainter trace of iron. The solution of sulphate of soda, from which the sulphuric acid of col. (3) was determined, exhibited a slightly yellowish-light-brown color, nothing similar to which occurred in any of the other experiments. A slight black residue remained when this silver was dissolved in nitric acid, and a trace of gold was detected in the residue.

‡ *Loc. cit.*

§ *Loc cit.*

of silver. Our memoir, already cited, gives the per cents. of lead found in two specimens of Vieille Montagne zinc. The standard of the American silver coin is ·9 silver and ·1 copper, and the weight of fifty cents' worth of this alloy, in either half-dimes, dimes, quarters, or a half dollar, has been 192 grains = 12·433 grammes, since the year 1853.*

Fine silver in the half-dollar, . .	11·190 grams.
Zinc used in reducing 11·19 grams. silver, .	6·742 "
Amount of lead in 6·742 grams. zinc, if the zinc contains 0·292 per cent. of lead, † .	0·0197 "
Amount of lead in 6·742 grams. zinc, if the zinc contains 0·494 per cent. of lead,† .	0·0333 "

If zinc of the best quality (containing 0·292 per cent. of lead) had been used, the silver coin would have contained 0·158 per cent. of lead; if the second quality (containing 0·494 per cent. of lead) has been employed, the coin may contain 0·268 per cent. of lead. Between these two limits, all our determinations of lead in American silver will be found to lie.

In offering this explanation of the occurrence of lead in American silver coin, we would by no means affirm that the zinc is the exclusive source of this impurity, for it is not at all improbable that a portion of the lead is derived from the leaden vats in which the reduction of the chloride of silver is effected, or from the sulphuric acid which is used to excite the reaction.

Protection of Iron and Steel.

Prof. Vogel Junior recommends, for the protection of iron and steel tools against rust, a solution of white wax in benzine. Moderately heated benzine dissolves half its weight of wax; and if this solution be carefully applied to the tool with a brush, the evaporation leaves a very adhesive and permanent coating of wax, which will preserve the metal even from the action of acid vapors.—*Dingler's Polytechnisches Blatt.—Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

On a new Method of Producing on Glass, Photographs or other Pictures, in Enamel Colors. By F. Joubert.

From the Journal of the Society of Arts, No. 444.

(Continued from page 179.)

Discussion.—Mr. Harvey inquired whether the method now employed for coloring daguerreotypes was applicable to the process just described, provided the colors used were such as to stand the firing.

M. Joubert replied in the affirmative—mineral colors being used

* Brightly's Dig. Laws U. S., for Standard, Title *Coinage*, s. 3; for Weights, Title *Coinage*, s. 13.

† See our Memoir in Mem. Amer. Acad. [N. S.], viii. 61, Table I.

instead of vegetable colors, as in the case of photographic coloring. The difference between the two was this:—Where they applied the color to a photograph, or drawing upon paper, the color remained as applied; but any one acquainted with glass painting knew that various colors were acted upon differently under the action of heat in the firing. For yellow color they used a preparation of silver and copper, and minerals were used more or less in the preparation of all the colors for burning in. If the colors were applied by the brush, as in the coloring of daguerreotypes, the process amounted, in fact, to that of glass painting, properly speaking, instead of its being a mechanical process as this professed to be. His (M. Joubert's) object had been to bring this invention to a purely mechanical result, so as to obviate the necessity of employing artists for glass painting. The object of the invention was to reproduce photographs or designs in a perfect form by mechanical manipulation.

Mr. Philip Palmer would express his obligations to M. Joubert for having brought forward this subject of window glass. Important as the subject was, within the last few years it had seldom been brought before the attention of this Society. It was now thirty years since he became a member of the Society, and he recollected that, at the first meeting he attended, the subject was that of window glass, and he believed the same subject had only been brought before them two or three times since. The Great Exhibition of 1851 afforded an opportunity for bringing this subject forward, and the approaching Exhibition of 1862 would, he hoped, probably furnish another occasion for doing so. With regard to the antiquity of glass, he might mention that in the British Museum there was a specimen of glass said to be of a date 3000 years before Christ. Whether that was the fact or not he did not know, but it was certain that some very old specimens of glass were to be seen in the British Museum. He quite agreed with the remark in the paper, that glass was so cheap and common that they were apt to lose sight of its immensely diversified qualities, and, therefore, any attempt to ornament it in this beautiful and artistic manner, deserved the strongest encouragement of all lovers of art. There was a period in the history of the importation of painted glass which was personally interesting to himself, and which was spoken of by Horace Walpole. It was matter of history, but was connected with his (Mr. Palmer's) great-grandfather, who imported large quantities of painted glass in 1753–4, and the circumstance gave rise to an amusing chapter in Walpole's letters. With regard to the cost of glass painting, he did not know that that was a subject which he ought to touch upon in the presence of several eminent glass painters whom he saw in the room, but he might venture to make this general remark —that a really good work of art must be well paid for; and if they employed first-rate talent, whether in painting upon glass or in architecture, that talent must be paid for; and glass painters were quite as much artists as those who painted upon canvass or paper. With regard to the decoration of glass at a moderate expense for the purpose of shutting out the view of dead walls, or a disagreeable neigh-

bor, M. Joubert had contrasted this process with the use of plain ground glass. That had been used for a great many years; enamel patterns had been produced in such immense quantities that the use of the latter had been much larger than that of plain ground glass. The patterns had become so common that architects were always seeking for something new. This process, as it appeared to him, was calculated to supply that want, inasmuch as it enabled persons to select any number of subjects and have them reproduced. Having been connected, as he and his family had been, for a century and a half with the glass trade, he wished to express his acknowledgments to M. Joubert for having brought this subject before them; and he would add, that he was quite sure all who were interested in the trade would be happy to give him the support which his ingenuity deserved, and to assist in bringing before the public this very beautiful invention.

Mr. Peter Graham would ask one or two questions of a practical nature. First, what was the largest surface to which this process had yet been applied, and whether there was any limit to the surface, and how many colors could be used in one picture. Also, whether there was any difficulty in employing a number of colors in combination, so as to produce a highly artistic effect; and, further, to what extent photographs could be enlarged or diminished, to bring them to such a size as might be required. He thought the invention might be applied to decorative purposes with good effect. He would also inquire what was the cost of these specimens, as compared with paintings upon glass of the same size, and whether many failures were experienced in the attempts to produce these pictures?

M. Joubert replied, with regard to the size, that the specimens he had exhibited, as being unburnt, $24 \times 17\frac{1}{2}$ inches, were the largest he had yet produced, but he apprehended the size was only limited by the dimensions of the kiln. There would, of course, be a little more care required in manipulating upon a large picture, but there would be no difficulty in producing a picture of three or four feet square. The only difference was the greater risk in burning it; the larger the surface of glass to be subjected to any manipulation or firing, the more the risk was increased. As to the combination of colors, if he understood the question aright, it was what combination of colors could be burnt at the same time. That was a question which he was scarcely in a position to answer with certainty at present. In the specimens upon the table, it would be observed that they were almost all of one color. He thought it better to produce them perfectly in monochrome in the first instance, and having mastered the difficulties of manipulation in one color, then to go to three or four colors. He would call attention to one specimen, having a colored border with an edging which had the appearance of ground glass. It was, however, produced by a coating of flux. The colored border was also added, and was burnt in at the same time with the white enamel—all in one firing—showing that a color and white enamel could be accomplished at the same time. He had been able to produce four colors in one burning. He had no doubt, with improved manipulation, a variety of

colors could be produced at one firing; but all glass painters were aware that to attempt to produce perfect copies of pictures, with all shades of colors, would be to branch into another line of art. Instead of being mere printing, it would become regular glass painting. It had been his object to avoid that from the first. Glass painting was executed very beautifully in this country, and upon that subject he might remark that an art which flourished 200 years ago seemed to have fallen into disuse for the last 100 years, and it was only at the beginning of the present century that glass painting had seemed to have revived. Although glass painting was not invented in England, he might say that this was the country in which that art had been kept alive more than in any other. The third question asked by Mr. Graham, was with respect to the size to which pictures could be enlarged or diminished. The camera was the instrument employed both for enlarging and reducing. The enlarging of designs through the camera was practised in Paris more extensively than in this country. In a short time there would be an exhibition here, in which objects would be shown as large as life. This process was in operation at present in Paris, but a large apparatus was now being prepared for introducing it into this country. They were aware that any photograph or drawing enlarged beyond a certain point was not pleasant to look at; and in proportion as a large picture diminished, it acquired finish; while, on the other hand, enlargement beyond a certain degree exaggerated the defects of the picture. With regard to the cost of these specimens as compared with ordinary glass painting, it was difficult to give an answer to that question, because there was no fixed price for glass painting with which it could be compared. The operations of the glass painter were exposed to many accidents. A work which had occupied many weeks or months, might spoil in the last firing; therefore the risk, being so considerable, was one reason why the price of glass painting must be arbitrary. Taking the average of the smaller specimens exhibited, he believed they could be sold at about 8*s.* per square foot. It was found necessary to fix the price according to measurement. If an architect had 100 square feet to cover, he must be able to estimate the cost without entering into the question of subject. He (M. Joubert) had no doubt when this invention was taken up generally by the manufacturers, the cost would be very considerably reduced. With regard to the failures he had met with, if he mentioned the number of failures he experienced at the beginning he should do a wrong thing, because in the early stage of an invention failures were frequent. Comparing the failures of the last three months with those that occurred two years ago, he might state that they were now only 1 per cent., whilst formerly they were as much probably as 50 per cent.

Mr. Phillips understood M. Joubert to state that this process could be applied to ceramic bodies. He begged to inquire whether it was equally applicable to china as to glass, and in that case, could it be applied to any description of form, as well as to a flat surface?

M. Joubert replied that, in the specification of his patent, he had

included ceramic substances as being part of the invention. He had already shown, to a few friends, some successful specimens of the application of this process to china; but he found that one branch of the subject at a time was quite enough to occupy his attention. He had chosen between the two, and had worked upon glass in preference; but that being now, as he considered, brought into good working order, his intention was to apply himself now to developing the invention with respect to china, because he was not only convinced that it would answer, but that it was possible to apply it to curved as well as to flat surfaces.

Mr. Gee inquired whether these subjects were liable to injury from external exposure to the weather or from the ordinary rubbing in the operation of cleaning glass?

M. Joubert replied, that the picture, forming an integral portion of the glass itself, could not be injured from the causes mentioned.

Mr. Gee, with reference to the applicability of the process to convex surfaces, inquired whether the subjects were not liable to distortion?

M. Joubert, in answer to that, would state, that an eminent photographer was about to introduce a method of printing photographs upon curved surfaces. He had seen some of those impressions which left no doubt upon his mind that his process would be applicable to all forms of glass or china. The subjects would not be distorted.

Mr. Bishop remarked, that when he was at Pompeii, about two years since, he was shown a piece of plate glass about three-sixteenths of an inch in thickness, which was the earliest specimen of plate glass he had met with.

M. Joubert was aware of the fact just mentioned, but there seemed to be some difficulty in establishing the fact that it was really glass. Some learned persons considered it was not glass, but merely a piece of transparent slate or mica that was used in ancient times, which, through the agency of fire, when those cities were invaded by lava, had assumed the appearance of glass. It was a great question whether it was glass.

Mr. Bishop said that that might have been the case as regarded Herculaneum, which was covered with melted lava, but in the case of Pompeii it was covered with wet cinders and mud, and therefore no vitrification could have taken place. The specimen to which he alluded, was about one foot by nine inches; he had carefully examined it, and should pronounce it to be glass, resembling as nearly as possible the material of the present day known as cast plate glass.

M. Joubert had not seen the specimen alluded to by Mr. Bishop, and could, therefore, give no decided opinion upon it; he could only judge from the reports he had heard from other persons. A distinguished glass manufacturer (Mr. Chance) read a paper before this Society some years ago, in which he stated that glass had been found in the ruins of Pompeii. Upon reading that, he (M. Joubert) was somewhat startled at the assertion, because he was intimately acquainted with persons who had traveled there, and who had made this sub-

ject matter of special investigation, but they had told him it was very doubtful whether it was glass at all. He should not like to decide against the opinion of a gentleman who had seen the thing itself, as his opinion was founded entirely upon the statement of others.

Mr. B. Waterhouse Hawkins said as M. Joubert had submitted to his catechism with so much patience, he begged to trouble him with one more question. As he had included ceramic manufactures in the category of materials susceptible of receiving the benefit of this wonderful invention, he (Mr. Hawkins) would ask whether he had taken into his consideration the possibility of applying this beautiful process to the cheap decoration of ceramic ware, porcelain, and ordinary pottery, so that they might ultimately hope for the banishment of the "willow pattern," and the substitution of varied and more artistic patterns produced by photography, and whether there was a probability of their being so cheaply produced as that they could be multiplied in the same manner, and nearly as cheaply as the present mode of printing upon biscuit.

M. Joubert would be glad if he could candidly say that he even saw, looming in the distance, a prospect of applying this process to the displacement of the old willow pattern upon our crockery, but at present he did not think there was much prospect of this, and for this reason:—these pictures were all printed photographically, and every one knew that the process was not very rapid, the operation being liable to be more or less influenced by the state of the weather; but he was quite confident that some day or other the present mode of printing, which was applied to photography generally, would be superseded by the discovery of a mode of producing a perfect metal plate, engraved by means of photography itself. When that was accomplished, no doubt one of its first practical applications would be to the patterns of pottery wares, and they might then have a chance of bidding adieu to the willow pattern for ever.

Mr. Wm. Hawes did not rise for the purpose of putting more questions to M. Joubert, but if he were inclined to make an observation upon the very able paper they had heard, and the discussion which had followed upon it, it would be to express the great satisfaction they must all have felt at the manner in which the various inquiries had been replied to by M. Joubert. They must have arrived at the conclusion, from what they had heard, that here was a new application of one of the newest and most recent discoveries connected with the art and industry of the present day. Photography, a young art, was applied in a new form, and with great facility, to produce most beautiful effects; and they had been told with a degree of fairness and candor which made them feel satisfied that every word was true, that, in the experience of only two years, so great a proficiency had been attained, that, whereas the failures were formerly fifty per cent., they were now reduced to not more than one per cent. They had also been told, incidentally in the discussion, that the art of painting upon glass had fallen into neglect for a considerable period in this country, but had again progressed within the last few years. It was

about 120 or 130 years ago that the excise was put upon glass. The effect of that interference was to check the application of glass to the most beautiful purposes of domestic life. About 100 years ago, the art of painting on glass relapsed, and had only recently revived. It was singular that that should be just about the time when the excise was put upon glass. If that fact was incorrect, his reasoning would fail; but he deduced this conclusion from it—that this was another instance that where there was entire freedom of a manufacture from fiscal imposts, men like M. Joubert could study and experimentalize at comparatively little cost, whereas, if the law put a high duty upon this material, the cost alone would almost have prevented the advancement of such an invention as this. No one could doubt that if M. Joubert could produce designs of this kind, at a cost of 8*s*. per foot, in the present stage of the invention, in a few years time they would be produced at a price which would bring them into common use. It only wanted more practice, more experience, and manufacture on a larger scale, to reduce the present price of 8*s*. to almost a nominal sum. The photograph itself was almost costless; the skill was in the transferring of it. This beautiful invention, he had no doubt, would in a short time become an important element in the ornamentation of their houses. With regard to the probability of this invention ever superseding the willow pattern, he believed, in point of economy, that would hardly be achieved, because the printing such designs as the willow pattern was the cheapest process that could be conceived or introduced. As a member of the Council he begged to express his thanks to M. Joubert for bringing a subject of this kind so ably before them. Generally speaking, he had a strong objection to patentees making use of this Society as a means of disseminating their own views with regard to their own patents. But this was an extraordinary case. Here was not only a patent brought before them, but a beautiful and novel application of art, and it was the duty of this Society, whose main object was to encourage the arts, to give an opportunity of bringing it thus before the public, especially when it was brought forward with such candor as had been shown on the present occasion.

Mr. Philip Palmer apologized for his interruption of Mr. Hawes' remarks, with which he agreed, except as to the excise duty upon glass having stopped the art of painting upon glass. M. Joubert had not hinted at such a thing, and he was afraid his friend Mr. Hawes had adopted the popular opinion as to the effect of the repeal of the duty on glass. If the repeal of that duty had done anything, it had had the effect of making the manufacture of glass a monopoly instead of an open trade. At the time the duty on glass was repealed, there were twenty manufacturers; at the present time there were only six. A much larger quantity of glass was produced, but six houses were sufficient to manufacture what was formerly produced by twenty. The question of the value of glass, in his opinion, had very little to do with the cost of producing these pictures. A piece of glass which now cost sixpence or ninepence, was not worth more than double that

sum when the duty was in existence; so that, previous to 1845, M. Joubert could have produced his designs at the same cost plus the extra price of the glass at that time compared with the present. He could not consider that the imposition of an excise duty upon glass had had the effect of checking the art of painting on glass, but he rather attributed the disuse spoken of to the want of taste of the period. They knew in what a low state the arts were in this country a century ago, and it was only right to say that this Society was one of the means of keeping alive a taste for art.

M. Joubert, in mentioning the average price of 8*s.* per square foot, wished it to be understood that the remark applied to the smaller specimens on the table. With reference to what had fallen from Mr. Hawes upon the subject of the duty upon glass, he (M. Joubert) would say that he so far concurred in what that gentleman had said, that if glass had been as expensive now as it was before the repeal of the duty, he did not think he should have ventured to engage in this process at all.

Mr. Hawes further remarked that this was not the place to enter upon an argument as to the effects of the repeal of the duty upon glass. There might have been twenty manufacturers before the repeal, and there might be only six now; but if the six could now do that which the twenty did before, the public were no losers by that circumstance. To adopt Mr. Palmer's reasoning was to go back twenty or thirty years in their commercial policy. They had before them the fact just stated by M. Joubert, that if the experiments which had led to the perfection of this process had had to be performed upon an article bearing a high excise duty, the cost of the experiments would have been such as to have deterred him from undertaking them.

The Chairman said the agreeable duty now devolved upon him of expressing, not only his own views, but he believed the views of the meeting at large, upon the beautiful and novel invention which had been brought before their notice that evening. They sometimes saw decorations of windows which, though beautiful within, had a very unsightly appearance from the outside; but here they had both sides equally beautiful. It was an invention of a peculiar kind. It was pure photography applied to glass, with this addition, that it was burnt into the substance of the glass, and became as durable and indestructible as the glass itself; and this he apprehended constituted one of the chief merits of the invention. It would enable them, he trusted, before long, to obtain copies of beautiful pictures for decorative purposes, at comparatively small cost. They would not have to form the designs themselves, or to employ expensive artists to execute them; but, by the aid of the photographer, they might have reproductions of the works of Raphael, or even actual scenes from nature. There was one specimen in particular to which he would call their attention. It was a scene of some Frenchmen reading a proclamation in Paris during the late Italian war. In this way, portraits of friends might be employed in the ornamentation of their dwellings. It was the combination of the two great arts of photography and enameling. It had

this superiority over paper photographs; a strong suspicion prevailed that photographs would not last for ever, that the effects produced by the action of light might be destroyed by the light; but by this process the impression was rendered as durable as the glass itself. He was sure the feeling of the meeting would be with him when he expressed the gratification which this novel and interesting application of the photographic art had afforded them. He entertained the highest sense of the value of this paper; but what enhanced its value, were the answers given by M. Joubert to the many inquiries which had been put to him. He did not over-answer the questions, but when he dealt with matters which were more subjects of surmise than of actual experience, he replied with a modesty and talent which carried with it, to his (the Chairman's) mind, a perfect conviction of his sincerity, as well as of his practical ability.

The vote of thanks having been passed,

M. Joubert returned thanks for the kind manner in which his paper had been received. He could not allow this meeting to separate without conveying to every person present, as far as he was able to do so, his extreme feeling of gratification for the manner in which he had been received as a stranger in this country, and especially in this Society, since he had had the honor of being a member of it. If bringing this invention before them, which had cost him some labor and anxiety to perfect, had been the means of ministering to their gratification and enjoyment, he felt he was only attempting to repay the debt of gratitude which he owed to the people of this country.

A Substitute for Silver.

From the Lond. Mechanics' Magazine, June, 1861.

Messrs. De Ruolz and De Fontenay have lately obtained, after several years experiments, a new alloy, which may be very useful for small coin and for many industrial uses. It is composed of one-third silver, 25 to 30 per cent. of nickel, and from 37 to 52 per cent. of copper. Its inventors propose to call it *tiers-argent*, or tri-silver. Its preparation is said to be a triumph of metallurgical science. The three metals, when simply melted together, form a compound which is not homogeneous; and to make the compound perfect, its inventors have been compelled to use phosphorus and certain dissolvents which they have not yet specified. The alloy thus obtained, is at first very brittle; it cannot be hammered or drawn, and lacks those properties which are essential in malleable metals. But after the phosphorus is eliminated, the alloy perfectly resembles a simple metal, and possesses in a very high degree the qualities to which the precious metals own their superiority. In color it resembles platinum, and is susceptible of a very high polish. It possesses extreme hardness and tenacity. It is ductile, malleable, very easily fused, emits when struck a beautiful sound, is not affected by exposure to the atmosphere, or to any but the most powerful reagents. It is without odor. Its specific gra-

vity is a little less than that of silver. An alloy possessing these properties must be very useful to gold and silver smiths. It can be supplied at a price 40 per cent. less than silver, and its greater hardness will give it a marked superiority. It may also serve as a substitute for gold-plated or silver-plated articles, which are now so common on account of their cheapness, but which will not bear re-plating more than a few times, and which are, in the long run, sometimes more expensive than the pure metal. The new alloy, however, will be most useful for small coin. Its preparation and coining are so difficult that the coin made of it cannot easily be counterfeited. Its hardness would render it more durable than silver; and thus the expense of re-coining, and the heavy loss arising from the wearing of our silver coinage, would be greatly diminished.

Liquid Diffusion applied to Analysis. By Thomas Graham, Esq., F. R. S., Master of the Mint.

[From the Proceedings of the Royal Society, No. 44.]

The unequal diffusibility of different substances in water appears to present means of separation not unlike those long derived from unequal volatility. For as regards diffusion, there exists a "volatile" and also a "fixed" class of substances; and these distinctions appear to correspond with differences in molecular constitution of a fundamental nature. Much value is attached to diffusion, as affording the means of bringing out clearly, and subjecting to numerical expression, the distinctive properties of what appear to be two great divisions of chemical substances.

The first, or *diffusive*, class of substances, are marked by their tendency to crystallize, either alone or in combination with water.

When in a state of solution, they are held by the solvent with a certain force, so as to effect the volatility of water by their presence. The solution is generally free from viscosity, and is always sapid. Their reactions are energetic and quickly effected. This is the class of *crystalloids*.

The other class, of low diffusibility, may be named *colloids*, as they appear to be typified by animal gelatine. They have little if any tendency to crystallize, and they affect a vitreous structure. The planes of the crystal with its hardness and brittleness, are replaced in the colloid by rounded outlines with more or less softness and toughness of texture. Water of crystallization is represented by water of gelatination. Colloids are held in solution by a feeble power, and have little effect on the volatility of the solvent. They are also precipitated from their solution by the addition of crystalloids. The solution of colloids has always a certain degree of viscosity or gumminess when concentrated. They appear to be insipid or wholly tasteless, unless when they undergo decomposition upon the palate, and give rise to sapid crystalloids. Their solid hydrates are gelatinous bodies. They are united to water with a force of low intensity; and such is

the character of the combinations in general between a colloid and a crystalloid, even although the latter may be a powerful reagent in its own class, such as an acid or an alkali. In their chemical reactions, the crystalloidal appears the energetic form, and the colloidal the inert form of matter. The combining equivalent of the colloid appears always to be high, and it has a heavy molecule. Among the colloids rank hydrated silicic acid, and a number of soluble hydrated metallic peroxides, of which little has hitherto been known; also starch, the vegetable gums and dextrin, caramel, tannin, albumen, and vegetable and animal extractive matters. The peculiar structure and chemical indifference of colloids appear to adapt them for the animal organization, of which they become the plastic elements.

Although the two classes are widely separated in their properties, a complete parallelism appears to hold between them. Their existence in nature appears to call for a corresponding division of chemistry into a crystalloid and a colloid department.

Although chemically inert in the ordinary sense, colloids possess a comparative activity of their own, arising out of their physical properties. While the rigidity of the crystalline structure shuts out external impressions, the softness of the gelatinous colloid partakes of fluidity, and enables the colloid to become a medium for liquid diffusion, like water itself. The same penetrability appears to take the form of a capacity for cementation in such colloids as can exist at a high temperature. Hence a wide sensibility on the part of colloids to external agents. Another eminently characteristic quality of colloids, is their mutability. Their existence is a continued metastasis. A colloid may be compared in this respect to water while existing liquid at a temperature below its usual freezing point, or to a supersaturated saline solution. The solution of hydrated silicic acid, for instance, is easily obtained in a state of purity, but cannot be preserved. It may remain fluid for days or weeks in a sealed tube, but is sure to gelatinize at last. Nor does the change of this colloid appear to stop at that point. For the mineral forms of silicic acid, deposited from water, such as flint, are found to have passed, during the geological ages of their existence, from the vitreous or colloidal into the crystalline condition (H. Rose). The colloidal is in fact a dynamical state of matter; the crystalloidal being the statical condition. The colloid possesses ENERGIA. It may be looked upon as the probable primary source of the force appearing in the phenomena of vitality, as living matter without form. To the gradual manner also in which colloidal changes take place (for they always demand time as an element), may the chronic nature and periodicity of vital phenomena be ultimately referred.

For the separation of unequally diffusive crystalloids from each other, jar-diffusion was had recourse to. The mixed solution was conveyed by means of a pipette to the bottom of a column of water contained in a cylindrical glass jar. A kind of cohobation takes place, a portion of the most diffusive substance rising and separating from the less diffusive substances, more and more completely, as it ascends.

The separation of a crystalloid from a colloid is more properly effected by a combination of diffusion with the action of a septum composed of an insoluble colloidal material. Animal membrane will serve for the latter purpose, or a film of gelatinous starch, hydrated gelatin itself, albumen, or animal mucus. But by much the most effective septum used was paper, as it is metamorphosed by sulphuric acid (Gaine). It is now supplied by Messrs. De la Rue, and has become familiar under the name of "vegetable parchment" or "parchment-paper." From sheet gutta-percha a flat hoop is formed, eight or ten inches in diameter by three inches in depth, and one side is covered by a disc of parchment-paper, so as to form a vessel like a sieve. A mixed solution, which may be supposed to contain sugar and gum, is placed upon the septum to a depth of half an inch, and the instrument then floated upon a considerable volume of water contained in a basin. Three-fourths of the sugar diffuses out in twenty-four hours, and so free from gum as to be scarcely affected by subacetate of lead, and to crystallize on the evaporation of the external water by the heat of a water-bath.

The unequal action of the septum, which causes the separation described, appears to depend upon this: The crystalloid sugar is capable of taking water from the hydrated colloidal septum, and thus obtains a medium for diffusion; but the colloid gum has little or no power to separate the combined water of the same septum, and does not therefore open the door for its escape by diffusion, as the sugar does. This separating action of the colloidal septum is spoken of as *dialysis.*

Dialysis was applied to the preparation of various colloids. The mixed solution obtained by pouring silicate of soda into water acidulated with hydrochloric acid, was placed upon a parchment-paper dialyser and allowed to diffuse into water, the latter being occasionally changed. After the lapse of five days seven-eighths of the original silicic acid was found to remain liquid upon the septum, and to be so free from hydrochloric acid and chloride of sodium as not to give a precipitate with acid nitrate of silver. The true hydrated alumina, and also Mr. Crum's metalumina, were obtained soluble by dialysing solutions of these oxides in the chloride and acetate of the same metal. So also the hydrated peroxide of iron, in addition to the hydrated metaperoxide of iron of M. Péan Saint Gilles, and the soluble hydrated chromic oxide. The varieties of prussian blue are obtained soluble by dialysing their solution in oxalate of ammonia, the latter salt diffusing away. Stannic and titanic acids appear as insoluble gelatinous hydrates.

A solution of gum-arabic (gummate of lime), dialysed after an addition of hydrochloric acid, gave at once the pure gummic acid of Frémy. Soluble albumen is obtained in a state of purity by dialysing that substance with an addition of acetic acid.

Caramel of sugar, purified by repeated precipitation by alcohol and afterwards by dialysis, contains more carbon than any of the caramelic bodies of Gélis; it forms a tremulous jelly when concentrated, and appears decidedly colloidal. Caramel, like other colloids, has a

soluble and an insoluble modification. The latter has its solubility restored by the action of alkali, followed by that of acetic acid and subsequent dialysis.

Dialysis proves highly useful in separating arsenious acid and metallic poisons from organic fluids. Defibrinated blood, milk, and other organic fluids charged with a few milligrammes of arsenious acid, and placed upon the dialyser, were found to impart the greater proportion of the arsenious acid to the external water in the course of twenty-four hours. The diffusate was so free from organic matter, that the metal could be readily precipitated by sulphuretted hydrogen, and the quantity weighed.

Ice at or near its melting-point appears to be a colloidal substance, and exhibits a resemblance to a firm jelly in elasticity, the tendency to rend, and to reintegrate on contact.

The consideration of the properties of gelatinous colloids appears to show that osmose is principally an affair of the dehydration of the gelatinous septum under influences having a catalytic character, and that the phenomenon is independent of diffusion. The colloidal septum is capable of hydrating itself to a higher degree in contact with pure water than in contact with alkaline solution. Colloidal septa, swollen in consequence of contact with dilute acid or alkali, appear to acquire increased sensibility to osmose, in consequence of their unusually high degree of hydration.

Steam Engine and Boiler Experiments at the Scotland Street Iron Works, Glasgow. By Mr. William Tait.

[Read at the Institution of Engineers of Scotland.]

From the Lond. Mechanics' Mag., January, 1861.

Three years ago, the writer commenced a series of experiments for the purpose of verifying in some measure the advantages alleged to be derived from the use of high-pressed steam, worked more or less expansively, as compared with steam of a lower pressure, worked in the usual way. Those experiments, however, were soon abandoned, because the engine was very often worked late, and occasionally all night, with a load at night probably not more than one-half of that which constituted the day's work. It was also found inconvenient to attend at night to take pressure diagrams. Similar experiments were again instituted a few months ago, and although not so complete as were originally intended, they may yet be interesting to those occupied with similar pursuits. The economic conditions under which a given weight of coal is made to perform a given amount of work, form an important object of inquiry.

The experiments were commenced with steam at a pressure on the safety valve of 55 lbs. per square inch, cutting off the steam in the cylinder at one-sixth of the stroke. These experiments were meant to be continued from week to week, and on each succeeding week with four inches more steam in the cylinder, until three-fourths of the stroke was arrived at; but this intention was departed from in consequence

of the very irregular and often excessive quantity of coal required to keep up the steam. This irregularity arose from the circumstance of the boiler top being wholly unprotected from the weather, in consequence of which, when winter came, with rain and snow, the consumption of coal was increased from 25 to 30 per cent. over the usual average quantity. The experiments were therefore discontinued for a few days until the boiler and steam-pipes were covered—the boiler with hair-felt and bricks, and the pipes with felt, saw-dust, and wood.

On Monday, 12th December, 1859, the experiments were resumed with the expansion valve set to cut off the steam at one-fifth of the stroke, and were continued until Saturday, 31st December—three weeks; and from Monday, 9th, until Saturday, 14th January, 1860, being four weeks in all, or 240 hours. Diagrams were taken several times a-day, and the mean accepted as showing the actual quantity and force of the steam in the cylinder. M'Naught's indicator was used, and its accuracy was occasionally tested both on the boiler and valve casing alongside of Bourdon's pressure gauges, the one in fact checking the accuracy of the other. The coal was accurately weighed, and the quantities recorded represent every pound that was consumed, including the getting up of the steam in the mornings, gathering the fire at night, and on Sundays. The ashes and clinkers were also carefully weighed.

The evaporation was tested by measuring accurately the surface area of the water in the boiler, and noting its height on the gauge glass before starting the engine at 10 o'clock, A. M., and at 2 o'clock, P. M., and stopping again at 12 o'clock, and at 5 o'clock, P. M., until respectively the fall of the water was ascertained. The engine was stopped for the purpose of letting the water be as quiescent as possible. This again was partially checked by noting the quantity of water taken from a cistern.

The boiler is 32 feet 6 inches long, by 5 feet 2 inches in inside diameter, with two flues passing through it longitudinally, each 18 inches in inside diameter. The fire-grate measures 4 feet by 3 feet 3 inches, and the ash-pit is fitted with doors. On the centre of each door is a fan valve for regulating the admission of air. The wall at the side of the grate nearest the chimney is built close up to the boiler. There are air-holes in this wall, the air being supplied by a valve in front of the building. This air is of course to aid in abating the smoke nuisance. The furnace bridge rises to within five inches of the boiler, allowing about 510 square inches for the passage of the gases, or about 40 inches per foot of fire-grate. There is no part of the outer shell of the boiler exposed to the action of the fire excepting the part above the furnace, and onwards to where the flame turns upwards to the flue tubes. The recipient surfaces computed by the usual method are equivalent to about 23 H. P. Between the boiler and damper there is another bridge, which rises to a level with the centre of the tubes, the opening over it being about 300 square inches. The gases, after passing this bridge, descend and pass beneath the damper into the chimney. The steam-pipe to the engine is 49 feet long by 5 inches in

diameter, and is carried through the chimney at a certain point, where it is divided into four pipes made of copper, and joined to the iron pipe in the brick-work of the chimney. These pipes possess in all about 26 feet of surface, and may take up a little, a very little of the heat manifestly going to waste up the chimney.

The engine is high-pressure, with cylinder 20 inches in diameter, and a stroke of 4 feet, and it made with great regularity 34 strokes per minute—this at any rate being the mean velocity. The cylinder in not jacketed, and has no covering of any kind. The slide-valves are worked by eccentrics both for steam and expansion. Figs. 1 and 2 represent two pairs of top and bottom diagrams taken from the cylinder.

The following are the data and mean results of four weeks observations:—

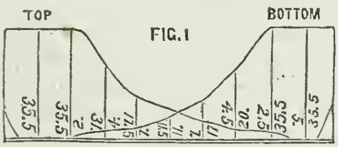
Length of boiler,	32 ft. 6 ins.
Diameter of do. (internal),	5 ft. 2 ins.
Number of flues,	Two.
Diameter of do. (internal),	1 ft. 6 ins.
Area of under surface of boiler exposed to the fire,	61 ft.
Do. end of boiler exposed,	8 ft.
De. flues,	306 ft.
Heating surface per indicated H. P.,	10 ft. 7 ins.
Quantity of water in boiler (6 ins. above flues),	351 cub. ft.
Do. do. per H. P.,	10·028 cub. ft.
Steam space in boiler,	208 cub. ft.
Do. per H. P.,	5·94 cub. ft.
Area of fire-grate,	13 sq. ft.
Do. do. per H. P.,	53·5 sq. in.
Water evaporated per hour,	25 8 cub. ft.
Do. do. per H. P. per hour,	·73 cub. ft.
Time of working,	240 hours.
Coals consumed,	68,544 lbs.
Do. per hour,	285·6 "
Do. per H. P. per hour,	8·08 "
Pounds of water evaporated per pound of coal,	5·65 "
Clinkers and ashes,	3509 "
Per centage of do. to the coals consumed,	5·1 per cent.
Thickness of fire-bars,	1 inch.
Spaces between do.,	$\frac{3}{8}$-inch.
Description of coal used,	Wishaw dross.
Heat of feed-water,	124° Fahr.
Pressure of steam in boiler,	40 lbs.
Do. in valve-casing,	40 "
Initial pressure on piston,	35 "
Average do. do.,	13·65 lbs.
Travel of piston before steam is cut off, nearly	10 ins.
Indicated H. P. (usual method), viz: area of cylinder × by effective pressure × by feet traveled per minute, / 33·000,	35·33
Length of steam-pipe,	49 ft.
Diameter of do.,	5 in.
Method of superheating. By 4 copper pipes through chimney $3\frac{5}{8}$ in external diameter—length 28 ft.—heating surface,	26·4 ft.
Temperature of steam in boiler at 44 lbs.,	292° Fahr.
Do. do. in valve-casing at 44 lbs.,	291° "

The temperature of the steam in the boiler and valve-casing was tried, for the purpose of ascertaining whether any and to what extent

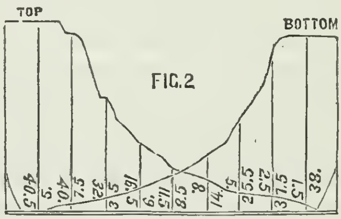
heat was imparted to the steam by the copper pipes in the chimney. In the valve-casing the temperature was 1° lower than in the boiler; the one was 2° and the other was 3° below what was due to the pressure. This discrepancy was no doubt owing to currents of cold air, and, at the valve-casing particularly, to the radiation of heat from the surface of the part where the thermometer was applied. At times, however, the temperatures were uniform and correct.

The pressure in the boiler and in the casing was indicated by Bourdon's gauges, and showed a nearly absolute uniformity—the greatest variation being from 1 lb. to 1½ lbs.; the excess being sometimes in the boiler and sometimes in the casing.

Regarding the quantity of coals consumed, it must be noted that the weather was nearly constantly wet during the experiments; the coals were brought in daily as required, and were weighed often when saturated with water; this water forming, in some instances, a large per centage. The weather also had an adverse effect on the boiler. The stock of coal in the work was kept small, to prevent the temptation to any excess in firing.



Mean H. P. 37·09.



Mean H. P. 37·265.

The steam-space in the boiler is noted, because it is large in proportion to the quantity of steam used at a single stroke of the engine; this quantity, including the filling of the steam-port, was about 2½ cubic feet, which was just about one eighty-third part of the steam in the boiler. This circumstance prevented in a great measure the liability of the water to pass off with the steam—water passing off in that way accounting satisfactorily for the apparently very great success attending many experiments on record; the success being in direct proportion to the amount of priming, or water carried off with the steam. It is doubtful whether or not any material benefit was derived from so partial an attempt at superheating as was tried in the present experiments.

The heat in the flue was high, and, on several occasions, melted zinc; in fact, it was melted on every repetition of the experiment if allowed to remain long enough in the flue. Five pounds of iron, after being hung in the flue for some hours, gave 6° of heat to a cubic foot of water, and copper gave the same result, whilst five pounds of fire-brick gave 8°. It would thus appear that the gases entered the chimney at a temperature of about 720° Fahrenheit. A close approximation to the temperature of the gases in a flue is obtainable by suspending a piece of iron in it until saturated with the heat, and then immersing it in six times its weight of water. The number of degrees of

temperature acquired by the water multiplied by 60 gives the temperature of the gases.

The writer has to express his regret that the intention with which he commenced these experiments has not been more fully carried out. Although he foresaw difficulty in arriving at strictly true comparative results, in consequence of the power of the engine being so much in excess of the work it had to perform, and of the continual variation in the quantity of that work, the difficulty has proved much greater than he ever anticipated, even without the subject of the comparative results to be obtained by different degrees of expansion having been entered on.

In a discussion which followed the reading of the preceding paper, Mr. Davison, from New York, said the boiler was of a form very common for high-pressure engines in America. Generally the fire was so placed as to allow the heat to pass first under the boiler and then through the flues, instead of passing first through the flues as in this country. That plan was adopted for safety and economy in fuel, the economy being generally more than that which Mr. Tait had recorded, with a greater proportionate fire-surface. The boilers were generally pretty well covered or protected from radiation.

Mr. Tait remarked that at first his furnace had an area of 19 square feet, but he had reduced it to 13 square feet; and for this reason, that the surface being so very large he had always too much steam when he had a fire upon the grate sufficient to cover the grate-bars.

Dr. Rankine asked what was the ratio of square feet of heating surface of the boiler to pounds of coal consumed per hour.

Mr. Tait answered that it was 285 lbs. of coal to a heating surface of 375 feet, or about 4 feet of surface to 3 lbs. of coal.

In answer to other questions as to whether the air-spaces in the furnace wall were not too small, and as to the heat of the water let into the boilers, Mr. Tait said that so far from that being the case, the damper of the furnace, which was 22 inches wide, had never to be raised above five inches. In fact, he could consume any reasonable quantity of coal in it. The draft was far too great for the size of the furnace. They had been feeding the boiler with water at 140°; but he expected that they would soon feed it with water at 180°.

Mr. Brownlee expressed his wonder that condensing engine-boilers should even be fed with water at less than 200°, it being so easy to have it heated even above that point.

Dr. Rankine said, that in high-pressure engines it seems to have answered well to condense the steam at 200° or thereabouts, and to feed in water to the boilers at 200°, or a little higher, and thus save the fuel. He believed that was done in Mr. Beattie's locomotives, and was found to save fuel considerably.

Mr. D. More said he had been much pleased with an inspection of the Scotland-street Engine Works; but it struck him that instead of reducing the size of the furnace, if the position of the fire had been changed, it would have been found that less of the heat would go up

the chimney. If the flues were extended he believed that little or none of the heat would in that way escape.

The President said Mr. Tait had been working at these experiments for a very long time, and had spent much of his time upon them, and they had cost a considerable sum of money, as all practical experiments did; and therefore he thought the Institution were much indebted to him. He proposed a vote of thanks to Mr. Tait accordingly, which was passed unanimously.

On White Gunpowder.

From the London Chemical News, No. 83.

Dr. J. J. Pohl has improved on Augendre's white gunpowder (*Sitzunsb. du Akad. der Wissenschaft zu Wien.* Bd. xli. s. 634). He prescribes the following quantities:—

Ferrocyanide of potassium,	28 parts.
Cane sugar,	23 "
Chlorate of potash,	49 "
	100

which give a well-burning powder, and nearly approaches the proportions

$$K_2 Fe Cy_3, 3HO + C_{12} H_{11} O_{11} + 3(KO\,Cl, O_5).$$

The results of the combustion of this mixture he calculates to be,

$$2K\dot{C}y + 3K\,Cl + Fe\,C_2 + N + 6CO + 6CO_2 + 14HO;$$

or, 100 parts by weight of the powder is resolved into

47·44	gaseous bodies,
52·56	solid residue.
100·00	

The volumes of the gaseous bodies he estimates as follows:—

Nitrogen,	1927·0	cub. centims.
Carbonic oxide,	8942·9	"
Carbonic acid,	8942·9	"
Steam,	20867·6	"
	40680·4	"

Compared with ordinary gunpowder, considered as unity, the results are said to be:—

	Ordinary powder.		White powder.
The volume of gas set free,	1	:	2·107
The temperature of flame,	1	:	0·641
The residue,	1	:	0·77

It should seem, then, that the new powder has over the old the advantages of greater power, igniting at a lower temperature, and leaving less residue. The author points out several other advantages: the ease with which the white powder is manufactured, there being no necessity for granulating and glazing, and the less danger of accidents. The higher price of the materials he considers is more than compensated for by the smaller quantity required.

A political and literary contemporary, who dabbles a little in science, and who describes the above composition as being *equally white and cleanly with common gunpowder*, dismally prophesies innumerable accidents if white gunpowder should ever come into use, in consequence of the explosive nature of chlorate of potash—a danger to which he, with wonderful prescience, says the author has never alluded. As it happens, Dr. Pohl is at pains to show that fears like those of our contemporary are groundless. Only, he states, the heaviest stroke of iron upon iron is sufficient to produce an explosion, and that it is impossible to ignite the powder by rubbing it between wood and metal, or between stones.

The Electric Light.

From the London Mechanics' Magazine, June, 1861.

The experiments with the electric light, which have now been made for a long time past at the Palais-Royal, Paris, are still continued every evening with increasing success. Lately, instead of two burners fed by divided currents from the magneto-electric machine, one burner, fed by a single current, has been used. It is raised sixteen metres, and illuminates, as with the light of the full moon, the whole square in front of the Palais-Royal, and the two entrances of Rue Saint Honoré. Two hyperbolic reflectors—one above the light, the other below—increase and diffuse the light. By certain improvements in the prisms or cylinders of artificial carbon, which are used in the production of the light, M. Curmer is now able to make electric lamps which will burn five or six hours without requiring any attention. The lamp of M. Serrin, placed before the house of Prince Eugene, also burns brilliantly. M. Serrin has succeeded lately in causing his lamp to burn under water almost as well as in the atmosphere. Thus, we may now light the bottoms of rivers, or of the sea, or the bottoms of floating vessels, sunken wrecks, the foundations of piers, and other submarine structures. It is expected that we shall soon be able to apply this method of illumination in our lighthouses, ships, and generally on land in our cities and houses. At the Invalides lately, in the presence of Despretz, Babinet, Foucault, and others, a magneto-electric machine was worked by one of Lenoir's lately-invented gas-engines, of 3-horse power. By this means, a strong electric current was generated, and M. Serrin's lamp gave a very brilliant light, equal to two hundred Carcel burners.

Making of Ice artificially.

In a former number of our *Journal*, we described the apparatus invented by M. Carré, for freezing water by means of the evaporation of ammoniacal gas. Our description was taken from the *Cosmos;* we now take from the same journal the following description of the apparatus established upon a practical scale, and arranged so as to work perpetually.

The generator contains in its lower part, which is called the *boiler*,

190 lbs. of an ammoniacal solution at 28°. Under the action of the heat, the ammoniacal gas is disengaged, and passes into a second compartment which encloses a series of superposed horizontal tubes, with large vertical tubulors in the middle; this set of tubes performs the function of a rectifier; that is, the gaseous ammonia disengaged by the heat comes in contact in these tubes with the liquid returning to the boiler, gives up to it its vapor of water, and passes to a state of almost absolute purity. From the *rectifier*, the gas passes into a worm, and from this to a *liquefier;* a collection of tubes around which is a current of water, at a temperature of from 53° to 59° Fah. On coming out of the liquefier, the ammonia, now liquid, and still pushed on by the pressure in the boiler, which is some ten atmospheres, enters another vessel called the *regulator*, in which floats a bell with very thin metallic walls, which, by its successive risings and fallings, regulates the discharge of the liquid, and prevents the mixture of any bubbles of gas. Thus condensed, the liquid passes through the induction valve into the *refrigerator*, which is a worm wound several times around the cylinders filled with the water to be frozen, which are placed in a vat of an uncongealable liquid, such as a strong alcohol, or, better, a sufficiently saturated solution of *chloride of calcium* (*muriate of lime*).

After resuming the gaseous form, at the expense of the heat of the water in the cylinders, and thus freezing it, the ammonia leaves the worm by a vertical tube, fills a central bottle, and comes into the *absorber*, where it comes into contact with the water exhausted of its ammonia, passing from the bottom of the boiler, and minutely divided by passing through a great number of small holes. There the ammoniacal solution is re-formed, with a disengagement of heat, which is absorbed by circulating again through cold water; finally, from the *absorber*, the ammoniacal solution passes into the boiler by its top, and passes through the tubes of the *rectifier*.

The ice forms very rapidly, and is very solid and opaque; its temperature is about 12° Fah., so that it is not necessary to wait until the water of the cylinders freezes to the centre, as the action goes on after the cylinder is withdrawn. The cylinders are removed every 8 minutes, and the ice of each one weighs about 9 lbs. With an expense of 5·5 lbs. of coal burned, there is obtained 55 lbs. of ice per hour, and this ratio will increase with the capacity of the apparatus; so that when 200 or 2000 lbs. are made per hour, the price of the ice will not exceed $2·25 per ton.—*Cosmos.*

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, September 19, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President, } Present.
Isaac B. Garrigues, Recording Secretary, }

The minutes of the last meeting were read and approved.

Donations to the Library were presented by the Chemical Society, of London; la Société d'Encouragement pour l'Industrie Nationale, Paris, and la Société Industrielle de Mulhouse, France; the Osterreichischen Ingenieurs Verienes, and the Néider Osterreichischen Gewerbe Vereines, Vienna, Austria; the Natural History Society of Montreal, Canada; the Mercantile Library Association of the City of Brooklyn, New York; John Warner, Esq., of Pottsville, Penna.; L. Blodget, Esq., Frederick Fraley, Esq., the Councils of the City of Philadelphia, and Profs. J. A. Meigs, J. C. Cresson, and John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of July was read.

The Board of Managers and Standing Committees reported their minutes.

The candidates proposed at the last meeting were duly elected members of the Institute.

Ulric Dahlgren, Esq., exhibited and explained to the meeting the following Photographs, which were viewed with much satisfaction by the members, being of a large size, and well executed works of art. They consisted of:—

A Chinese Fort, at Peiho, captured by the French and English, Aug. 21st, 1860; showing the exterior, where an entrance was forced through a breach in the upper wall by means of scaling ladders, after first breaking down and removing the palisades which had been stuck around the Fort for some distance, with pointed ends, to prevent the approach of an enemy.

Three Interior Views of the same portion of the Fort, in different positions. Here the structure and composition of the wall can be seen, seeming to be of piles interlaced with light fastenings, and then filled out with clay and like substances. There are two tiers of guns, with roads at the angles to reach the upper one. Where the storming party entered, large numbers of the dead Chinese are visible; an English officer being the only one on their side remaining of the dead. These pictures were taken on the spot immediately after the fight; a set of them were obtained and brought over by Lieut. H. A. Wise, U. S. N.

Views of Naval Battery, showing the sailors at their guns ready for firing, and the town of Alexandria, Va., in the back-ground. This battery was sent from the Washington Navy Yard for the protection of Alexandria, and is a portion of the regular naval service. It is considered the finest and most efficient in the field, and is situated on Shuter's Hill.

Views of the Country between Washington and Alexandria, showing the different encampments in the Valley of the Potomac. Washington forms a prominent feature of the back-ground, with the Potomac meandering by it.

The position of Capt. Ward, U. S. N., and his crew, when he was killed. He had sent a party on shore to erect a battery at Mathias Point, on the Potomac River, and, meeting a large party of the enemy, attempted to escape from such superior numbers after nearly all were more or less disabled. Capt. Ward endeavored to drive back the enemy by shelling them from his vessel, the *Freeborn*, and, while in the act of aiming, was struck by a musket ball, and killed. This picture is intended to show the position of all on the vessel at the time, Capt. Ward being represented by a man who resembled him very much, and similarly attired. Being taken on the same vessel, it is a faithful picture.

The Officers of the 71st Regiment N. Y. S. M., as they happened to be together at the Washington Navy Yard, just before leaving for Bull Run, where several of them were killed.

Projectiles used by the Secessionists: 1st, A Shell fired from battery at Acquia Creek, during an engagement with the vessels of the Potomac Flotilla, June 1st, 1861. 2d, Shot fired at Bull Run, July 21st, 1861. 3d, Loaded Shell fired from Munson's Hill, Aug. 9th, 1861. These projectiles were all of an inferior model and make, and did their work imperfectly. The latter fell base first; it was loaded, and had a Boarman fuse in it, but did not explode. The lead on the bottom did not take the grooves of the rifle, and consequently did not have the rotatory motion necessary to keep it straight.

The Sawyer and the Shenkle Projectiles. The former is a shell of iron covered with a soft composition, and with flanches intended to fit the grooves of the rifle instead of having the metal expanded by the force of the powder, and to which latter arrangement it has given way. The peculiarity of the Shenkle projectile is in supplying the place of the soft metal on the base by papier-maché. Both are of an elongated shape, and pointed.

An Infernal Machine, used by the Secessionists. It consists of an iron cylinder, about 6 ft. long and 2 ft. in diameter, and perfectly water-tight. This is filled with 300 lbs. of powder. It is attached by ropes 6 ft. long to an empty hogshead, which supports it in the water, the side of the hogshead being exposed. An elastic tube is fitted water-tight, and connects the interiors of the magazine and barrel; through this tube the fuse runs, which is lighted through an aperture in the exposed side of the hogshead, and which, burning down till it reaches the cylinder, explodes it. The fuse would burn two hours. After being lighted and set loose, it was intended to float with the tide till it reached a vessel, and there remain, finally exploding. It was a very uncertain arrangement. There were two fastened by a rope several hundred feet long, but the other was lost.

These photographs were taken by the Photographer of the Ordnance Department, at the Washington Navy Yard.

METEOROLOGY.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

AUGUST.—The mean temperature of August (73·15°) was a degree and a half lower than the mean for eleven years, and two degrees below that of the same month last year. It was the coldest August on the record for the last eleven years, with the exception of August, 1856, of which the mean temperature was 72·15°.

The warmest day of the month was the 5th, of which the mean temperature was 85·2°. The highest degree of heat indicated by the register thermometer was 94° on the same day.

The coldest day was the 13th with a mean temperature of 62·5°. The thermometer indicated the lowest temperature (54·5°) on the morning of the 14th. The range of temperature for the month was 39·5°.

The greatest change of temperature in the course of a day, was 23·5°, on the 24th; the least was 6·5°, on the 29th. The average oscillation for the month (16·84°) was nearly two degrees less than that for August, 1860, but nearly one degree greater than the average for eleven years.

The greatest daily range of temperature was 12·7 degrees between the 11th and 12th; the least was 0·5 of a degree between the 1st and 2d. The average daily range for the month was 3·94°, which was a little more than the average for eleven years, and but one-tenth of a degree greater than for August, 1860.

The pressure of the atmosphere was greatest (30·212 inches) on the morning of 21st, and least (29·608 inches) on the morning of the 13th of the month. The mean daily pressure was least (29·661 inches) on the 10th, and greatest (30·160 inches) on the 21st. The average pressure for the month (29·906 inches) was greater than for any August since 1855, and was nearly four-hundredths of an inch greater than the average pressure for the last eleven years.

The greatest mean daily range of pressure for the month was 0·325 of an inch, between the 21st and 22d; the least was 0·018 of an inch, between the 7th and 8th; and the average for the whole month was 0·098 of an inch, which is five-thousandths of an inch greater than usual, and seven-hundredths of an inch more than for the same month last year.

The force of vapor and dew-point were greatest on the 5th of the month, and least on the 15th, and both were a little greater than the average for eleven years. The relative humidity was greater than for any August since 1853. It was greatest on the 29th, and least on the 15th and 31st of the month.

Rain fell on twelve days of the month, to the aggregate depth of 2·864 inches. This was nearly six and a half inches less than fell in August of last year; and two inches less than the average amount

for the month. The number of rainy days was greater than usual, though but a small quantity of rain fell at any one time. Rain fell in frequent showers during the 11th, 12th, and 13th days of the month, but during the whole time only an inch and a quarter fell at Philadelphia. It appears from the papers that, during the same days, a very great amount of rain fell in the Northern and Eastern States. The storm commenced with rain and a very strong wind in Chicago, on the 10th, and, passing slowly towards the east, reached Boston on the 13th. Considerable damage was done by the flood and wind in Chicago, Buffalo, southern Ohio, and New York.

There was but one day—the 15th—entirely clear, and the sky was completely covered with clouds at the hours of observation, on five days of the month.

A Comparison of some of the Meteorological Phenomena of August, 1861, *with those of* August, 1860, *and of the same month for eleven years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Aug. 1861.	Aug. 1860.	Aug. 11 years.
Thermometer.—Highest,	94°	95°	97°
" Lowest,	54·5	55	47
" Daily oscillation,	16 84	18·80	16·02
" Mean daily range,	3·94	3·80	3·78
" Means at 7 A. M.,	68 88	70·13	70·16
" " 2 P. M.,	79·52	82·87	80·63
" " 9 P. M.,	71·05	73·29	73·16
" " for the month,	73·15	75·43	74·65
Barometer.—Highest,	30·212 in.	30·026 in.	30·255 in.
" Lowest,	29·608	29·632	29·356
" Mean daily range,	·098	·090	·093
" Means at 7 A. M.,	29·912	29·848	29·882
" " 2 P. M.,	29 896	29·813	29 855
" " 9 P. M.,	29·910	29·834	29·873
" " for the month,	29·906	29·832	29·870
Force of Vapor.—Means at 7 A. M.,	·602 in.	·580 in.	·586 in.
" " " 2 P. M.,	·608	·584	·597
" " " 9 P. M.,	·612	·603	·613
Relative Humidity.—Means at 7 A. M.,	83 per ct.	78 per ct.	77 per ct.
" " " 2 P. M.,	60	52	57
" " " 9 P. M.,	79	73	74
Rain, amount in inches,	2·864 in.	9·260 in	4·546 in.
No. of days on which rain fell,	12	13	10·4
Prevailing winds—Times in 1000-ths,	S 85°55′E. ·088	N 80°54′W ·150	S82° 31′W ·085

Summer.—The mean temperature of the Summer of 1861 was 74·13°, which was about a degree and a half below that of the Summer of 1860, and about the same amount below the average for ten years. It was the coldest Summer for the last ten years, with the exception of that of 1859, of which the mean temperature was 73·79°.

The warmest day was the 8th of July, of which the mean tempera-

ture was 87·8°. The highest degree indicated by the thermometer was 95°, on the same day.

The coldest day was the 6th of June, which had a mean temperature of 55°. The lowest temperature was 51°, and was reached on the morning of the same day. The range of temperature for the Summer was 44°.

The average mean daily oscillation of temperature for the month was 18·23°; nearly two degrees above the average for ten years, and about one degree less than that of the Summer of last year.

The mean daily range—that is, the average difference of temperature between two consecutive days—was 4·31°, which was about a quarter of a degree above the average amount.

The pressure of the atmosphere was greatest (30·212 inches) on the 21st of August, and least (29·505) on the 20th of July; making the range for the season 0·707 of an inch.

The force of vapor, relative humidity, and the number of rainy days were greater than usual, while the quantity of rain was about two and a half inches below the average amount for the season, and more than three and a half inches less than the quantity which fell in the Summer of 1860.

A Comparison of the Summer *of* 1861, *with that of* 1860, *and of the same season for* ten *years, at Philadelphia, Pa.*

	Summer, 1861.	Summer, 1860.	Summer, for 10 years.
Thermometer.—Highest, . . .	95°	95·5°	100·5°
" Lowest, . .	51	52·0	42·0
" Mean daily oscillation,	18·23	19·20	16·33
" " daily range, .	4·31	4·33	4·12
" Means at 7 A. M., .	70·31	70·11	71·11
" " 2 P. M., .	80·55	81·71	81·35
" " 9 P. M., .	71·52	72·23	73·76
" " for the quarter,	74·13	74·68	75·40
Barometer.—Highest, . . .	30·212 in.	30·123 in.	30·281 in.
" Lowest, . . .	29·505	29·243	29·182
" Mean daily range, . .	·093	·097	·094
" Means at 7 A. M., .	29·832	29·805	29·856
" " 2 P. M., . .	29·801	29·769	29·825
" " 9 P. M., .	29·810	29·789	29·840
" " for the quarter,	29·814	29·788	29·840
Force of Vapor.—Means at 7 A. M.,	·552 in	·529 in	·574 in.
" " " 2 P. M., .	·553	·518	·585
" " " 9 P. M.,	·574	·547	·604
Relative Humidity.—Means at 7 A. M.,	74 per ct.	71 per ct.	74 per ct.
" " " 2 P. M.,	53	48	54
" " " 9 P. M.,	74	68	72
Rain, amount in inches, . . .	10·175 in.	13·817 in.	12·689 in.
No. of days on which rain fell, . .	41	33	33·1
Prevailing winds, ...	s61°23′w ·156	s82°27′w ·165	s73°11′w ·159

# JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

NOVEMBER, 1861.

CIVIL ENGINEERING.

Suspension Girder Bridges for Railway Traffic.

From the Lond. Civ. Eng. and Arch. Journal, Nov. and Dec., 1860.

The construction of four new bridges across the Thames, completed or in process, in the short distance between Hungerford Pier and Chelsea Reach, and designed on the several systems of suspension chains, arch, arch-girder, and girder, has the effect of bringing obviously before the eye of the public the working out of different theories of construction, which would otherwise be rather of a scientific or professional than of a general interest. It may therefore prove not unseasonable, nor perhaps wholly unprofitable, to dwell a little on the subject handled by Mr. P. W. Barlow, F. R. S., in his paper read before the British Association at Oxford.

Is it expedient, in the construction of bridges of large span for railway traffic, to employ chains, relying on a girder platform to reduce within safe limits the wave that inevitably accompanies the transmission of a rolling load over a common suspension bridge?

The question has been put to a practical test in Mr. Roebling's railway bridge over the Niagara; where a span of more than 800 feet is crossed by means of wire chains supporting a roadway and railway platform; the two platforms being so connected by means of trussing as to form a deep girder. In traversing this bridge the trains proceed at a foot-pace, and the accounts which reach this country as to the

degree of disturbance caused by their transit are somewhat conflicting. Its engineer is, however, understood to be as fully satisfied with the steadiness of the structure as he has every reason to be with the remarkably low cost. There is an additional safeguard against undulations in this bridge; cables being attached under the platform, and anchored to the rock below, thus serving as powerful stays: an excellent precaution, but one for which there would be no facilities in the majority of cases. A peculiar feature is the employment of a distinct set of chains for each platform; the deflection of one pair of chains being thus considerably greater than that of the other. It would follow that on any considerable change of temperature, the chains supporting the upper platform would naturally rise and fall appreciably more than those supporting the lower one; and as these platforms are firmly trussed together, it does not appear in what way the danger is avoided of an undue proportion of the weight of the entire structure being occasionally thrown on one set of chains. The extension of the chains when a heavy load comes on the bridge would tend to bring about a similar result.

There are, therefore, special circumstances about this bold and original work which prevent its being taken as a pattern or sample of suspension railway bridges; and very precise data must be obtained by means of careful observations before any general practical conclusions can be drawn from the success of the Niagara Bridge.

The question, then, of the suitability of suspension bridges with rigid platforms to the requirements of railway traffic, is as yet to be regarded as a matter of opinion; and there are few points on which the opinions of engineers of the greatest eminence and talent are less agreed than on the one now under consideration. The two master-spirits, who have left lasting monuments of their constructive genius in the railways of Great Britain, have strikingly exemplified the divergence of their views, in the bridges erected by the one over the Menai, the Conway, and the St. Lawrence; and, by the other, over the Wye and the Tamar.

The enormous strength and rigidity of the Menai tubes is such, that the addition of suspension chains would be simply useless, if not even detrimental. For the expansion and contraction due to extreme changes of temperature would cause the chains to rise and fall midway between the piers, to an extent to which the tube would not readily adapt itself; so that the main weight of the whole structure would sometimes be carried by the chains and sometimes by the tube. It was well known that Robert Stephenson was no advocate for the use of chains for railway bridges in any case. But, conclusive as the consideration just stated is against the combination of a chain with a beam of the proportionate strength of the Menai tube, it does not apply to a suspension bridge with a platform flexible enough to rise and sink as expansion or contraction may require; and at the same time stiff enough to insure the equable distribution of any partial load over the whole length of the chain.

The bridge over the Wye at Chepstow, and the very similar but

more colossal structure over the Tamar at Saltash, have much in common with the description of stiffened suspension bridge so strongly recommended by Mr. Barlow; but are distinguished by two main points of difference. In the first place the tension of the chains is sustained by straining-tubes resting on the summits of the piers, instead of by the ordinary stay-chains; in the second place, the platform girders are very slight, and the wave is prevented mainly by the introduction of iron trussing in the space between the tube and the chain.

Similar diversity of views may be seen exemplified at Chelsea and Hungerford. The massive chains of the new Chelsea Bridge, and the strong *gridiron* arrangement of the suspended girders, defy all the shocks and disturbances of common wheel traffic. At Hungerford a girder bridge is in course of construction, which would exhibit as marked a contrast to the fine suspension bridge of Brunel, as yet undisturbed, as the Britannia tubes present to the chains of Telford, at Menai. This new work seems to evince, on the part of its distinguished author, a persuasion that the use of chains is inadmissible under any circumstances in railway bridges; for, had it been thought practicable and safe to throw a suspended girder across the span of 670 odd feet, the existing piers would have presented singular facilities; the extent of the foundations being sufficient for a greatly increased width of roadway.

On the other hand, Mr. Barlow records a no less decided judgment on the part of Sir W. Cubitt and himself, that a simple suspension bridge, with a tubular girder roadway, may be traversed by railway trains with perfect safety and small disturbance.

It is therefore sufficiently clear, that if we consult the opinions even of the men most competent to pronounce on such a question, we are led to very opposite conclusions; and until the experiment is actually made on a large scale in some railway bridge, our only remaining resource lies in experiments on models, or in theoretic deductions.

The economy of the ordinary suspension bridge is mainly due to the property possessed by chains of adjusting themselves to any curve of equilibrium required by a new disposition of the load.

In the arch, if a load becomes so distributed as to throw the line of pressure near the edges of the voussoirs, the tendency of the thrust is to cripple the arch and destroy equilibrium. As a rolling load traversed the bridge, the line of pressure (in which the thrust is considered to be transmitted from the crown to the abutments) would, if it could be rendered visible, be seen to waver and distort itself. A bulge or swell would travel along it, raising it perceptibly at the successive points over which the load passed; and elsewhere it would be depressed and flattened. To insure the stability of an arch under all possible conditions, it is therefore necessary to give a far greater depth of voussoir, and consequently to employ a much larger amount of material than would be demanded simply to sustain the thrust. In girder arches there is a similar necessity for an excessive amount of material, either in the bow itself or in spandrels or trussing, to arrest change of form.

The effect of tension, on the other hand, is to guide the suspension chain into its position of stable equilibrium; so that if only sufficient play is afforded for spontaneous adjustment, no more material need be used than is required to sustain the simple strain of tension. A second advantage possessed by suspension over other wrought iron bridges results from the whole of the metal being employed to resist a tensile strain, no part being in compression. This causes a saving of material, on account of the strength of wrought iron to resist extension being considerably greater than its strength to resist compression. A third source of economy is one also shared in some degree by arches, and lies in the deep versed sine which can be given to the curve of the chains. The greater the versed sine, or rise, of the chain or arch, the less is the tension or thrust, and consequently the less is the material necessary to sustain it. An analogous reason renders it advantageous to increase the depth of a girder to a certain extent, but within far narrower limits; as the necessity of providing for lateral stiffness as well as the weight of webb or trussing absorbs much of the saving that would otherwise be effected in making girders very deep. A fourth advantage in favor of the suspension bridge is, that the reaction which maintains the tension of the chains is furnished by stay-chains attached to their extremities; while in the girder an upper flanch must be provided, the compression of which reacts against the extension of the lower flanch, giving a double amount of material in flanches alone, as compared with the chain. To all these reasons for the great economy of suspension bridges, add the important consideration that in considerable spans the weight of the bridge itself begins to bear a large proportion to the total load, a proportion which rapidly augments as the length of bridge is increased. It is thus that for spans of 300 or 400 feet the cost of the girder becomes enormously greater than that of the chain, and that suspension bridges can be thrown over spans utterly impracticable for any other kind of structure. Of course, in any viaduct it is of primary importance to avoid large spans as far as practicable. But cases will occur in which it is difficult or impossible to do so. Must the railway engineer in these cases forego the advantages peculiar to the suspension bridge? Further, in positions where the least practicable span exceeds the possibilities of a girder bridge, is he to reject the only description of structure that will meet the requirements of the case? If it is in the power either of experiment or of analysis to throw any fresh light on this vexed question, the study cannot be deemed unimportant or uninteresting.

Great allowances are necessary in drawing any conclusions as to a proposed work of considerable magnitude from experiments on a model, however carefully conducted. And, in fact, it is almost essential for theoretic analysis to go hand in hand with experiment, to assure us that we are justified in accepting such conclusions as valid guidance for a great work, especially if of a novel character. On the other hand, in analysis, if the reasoning is sound, and if we have ground for believing that nothing has been omitted or misstated in the data, there is a fair presumption of the correctness of the result: and if

this result is found to agree with experiment, few will hesitate to admit its truth.

It is therefore now proposed to inquire, what solution theory affords to the problem of the suspended girder; and while doing this it may be useful to note how far the results arrived at accord with Mr. Barlow's experiments. It will then be endeavored to indicate some general practical conclusions. It might have been of great help in such an inquiry to have been made acquainted with the course of reasoning pursued by Prof. Rankine, and to know the process by which the learned professor arrived at the conclusion cited in Mr. Barlow's paper. In the absence of the guidance which such knowledge might have afforded, it is necessary to proceed as upon untrodden ground.

If a weight be placed on any part of a girder suspended from a chain, but having its ends kept from rising at the piers, the chain will be observed to be drawn down by the loaded girder, and the further parts of the chain will be drawn up, drawing with them the girder. The girder will thus assume an S bend, with an additional half-bend in cases when the weight is applied near the half-span. What is the law of this compound displacement? The reason that part of the platform is drawn up when part is deflected, is obvious. The chain is fixed at the ends, and is of a certain length: when a partial deflection takes place, the curvature of the portion of chain immediately affected is increased, and this has the effect of *taking the slack out* of the rest of the chain (the total length being unchanged) by flattening its curvature; which at the same time draws it up, and the platform with it.

First of all, then, the law must be ascertained by which the vertical displacement of any portion of the chain affects the horizontal measurement from end to end. This law is as follows:—Let the variable y be the ordinate of the curve of the chain; and let the vertical displacements of the various points be plotted in a curve, of which the variable z expresses the ordinate. z is therefore, in fact, the total vertical displacement of any point in the chain, and is supposed to be inconsiderable compared with the total rise of the chain.

Let x be the abscissa, or horizontal distance. Then $\int \frac{dy}{dx} dz$ gives the total alteration of the horizontal measurement between any two given points of the chain, consequent on the supposed vertical displacements.

If now the wave of displacement of the platform can be resolved into two—namely, first a wave of simple deflection, in which the whole girder would sink under its load if unsupported by the chain, and, secondly, a reflex wave, in which the reaction of the chain pulls up the girder—we shall find the following relation to subsist between these waves. Call their respective ordinates z_1 and z_2: then

$$\int \frac{dy}{dx} dz_1 + \int \frac{dy}{dx} dz_2 = 0;$$

the integrals being taken for the whole distance from tower to tower. Because, apart from the stretching of the chain, which it is unneces-

sary at this moment to take into account, any other result would involve an alteration of the span, or a break in the continuity of the chain.

For a girder of a given uniform section, the wave of simple deflection may be determined by the ordinary rules. As the resistance of the girder to vertical displacements will be far more powerful than that of the chain, the displacements being very small compared with the versed sine of the curve of the chains, no serious amount of error is involved in assuming that the form of this wave depends absolutely on the girder, without reference to the chains.

We can therefore at once give an algebraical expression for z_1, the ordinate of the wave of simple deflection. Thence can be determined the value of $\int \frac{dy}{dx}\, dz_1 = \mathrm{H}$, the horizontal distance by which the span of the chains would be diminished through the wave of simple deflection, were the effect not compensated by the reflex wave.

The reflex wave must be of a form due to the action of an equally diffused upward pressure on the girder, since the curve of the chains (when the displacement is not considerable) may still be considered to be that due to equal loading; and the equal loading of the chain being conveyed through the suspension rods attached to the platform, the reaction on the platform must be equally distributed also. For similar reasons to those already adduced, the form of this reflex wave is deducible from the laws of girders simply. Its magnitude—and, in consequence, the proportion which the chains bear of the entire load—is determined by the equation

$$\mathrm{H} + \int \frac{dy}{dx}\, dz_2 = 0;$$

which gives the conditions on which alone the reflex wave can compensate the wave of deflection.

Having thus determined the simple wave of deflection and its ordinate z_1, and the reflex wave and its ordinate z_2; the superposition of the one wave on the other gives the actual compound wave of deflection with its ordinates $= z_1 + z_2$. The actual strain on the girder at any point will be found by subtracting from the strain accompanying the simple deflection the upward strain due to the reflex wave. In fact, the process of the analysis has regarded as successive two waves which are actually simultaneous; and by thus resolving the compound wave into its component parts, a solution is attained capable of simple and ready application.

If, for instance, it be inquired, what effect will be produced by a weight w placed on the suspended girder at a point distant d feet from the half-span (the ratio $\frac{d}{s}$ being expressed by r), it will be found, on pursuing the method of investigation just indicated, that a distributed pressure will be thrown on the chains

$$= \left(\frac{25}{16} - \frac{15}{2}\, r^2 + 5\, r^4\right) \times w;$$

and that the reflex wave due to the reaction of the chains will have its ordinate at the half-span

$$= k \times \frac{5}{6}\ \frac{s^3}{64}\left(\frac{25}{16} - \frac{15}{2}r^2 + 5\,r^4\right) \times w,$$

k being a coefficient depending on the rigidity of the girder, and s being the span. Combining the reflex wave with the simple wave of deflection (determined by the usual rules for girders), in which the same coefficient k will occur, the compound wave is obtained. A correction for the effect of the stretching of the chains, which goes to reduce the reflex wave, remains to be made, and the result is a very close approximation to the actual state of the suspended girder under the assumed conditions.

The case in which a single concentrated load produces the greatest wave, and causes the greatest strain to be thrown on the girder, is when it is placed at a distance midway between the half-span and one of the towers. A load of 256 cwt. placed in this position causes a distributed pressure on the chains equal to 285 cwt. This excess of 29 cwt. is due to the reaction of the further end of the girder, which is supposed to be fixed down to the pier by rollers, as it would otherwise be lifted from its seat by the tension of the chains. Let us compare the wave caused by a weight in this position with the deflection which the same weight would produce if placed in the centre of the girder, the support of the chains being withheld: w being the weight, and k the constant already referred to, $-k w \times \frac{s^3}{48}$ is the deflection which would follow were the girder not suspended, and the weight placed in the centre. To facilitate comparison we will therefore express the ordinates of the wave now under examination in terms of $\frac{k w s^3}{48}$.

First, the simple wave of deflection will have for its ordinates,

at the loaded quarter-span, . . $-0{\cdot}5625 \times \frac{k w s^3}{48}$

at the half-span, . . . $-0{\cdot}6875 \times \frac{k w s^3}{48}$

and, at the opposite quarter-span, . . $-0{\cdot}4375 \times \frac{k w s^3}{48}$.

The reflex wave will have for its ordinates,

at the loaded quarter-span, . $+0{\cdot}4959 \times \frac{k w s^3}{48}$

at the half-span, . . . $+0{\cdot}6958 \times \frac{k w s^3}{48}$

at the opposite quarter-span, . $+0{\cdot}4959 \times \frac{k w s^3}{48}$.

The addition of these ordinates will give the following as the ordinates of the resultant wave :—

at the loaded quarter-span (a depression), $-0{\cdot}0666 \times \frac{k w s^3}{48}$

at the half-span (a rise), . . $+0{\cdot}0083 \times \frac{k w s^3}{48}$

at the opposite quarter-span (a rise), $+0{\cdot}0584 \times \frac{k w s^3}{48}$.

The greatest deflection is, therefore, $-0{\cdot}0666 \times \frac{k w s^3}{48}$, or $\frac{1}{15}$th of the deflection due to the same load placed on the middle of the girder without chains. This result has, however, to be increased by the correction for the stretching of the chains.

The preceding result cannot be directly compared with those given by Mr. Barlow's experiments, because the reflex wave in his model is affected by the inequality in the height of the towers, which is such as to increase this wave by $\frac{1}{73}$d part when the load is placed one-fourth of span from the high tower, or to reduce it by the same amount when the load is placed one-fourth of span from the low tower. We will, therefore, take the mean of two experiments with the first girder, the load being 56 lbs.; in the first case, placed at quarter-span from the high tower, and, in the second case, at quarter-span from the low tower; and compare the mean so obtained with the deductions of theory.

The girder experimented on was one which, without the chains, deflected 1·2 ins. when a load of 42 lbs. was placed on the centre. In this instance, therefore, $\frac{k w s^3}{48} = \frac{1{\cdot}2}{42} \times w = \frac{w}{35}$. For the load of 56lbs. at the quarter span we have, therefore, to multiply the co-efficients of $\frac{k w s^3}{48}$, as above determined, by the fraction $\frac{56}{35}$, or $\frac{8}{5}$, in order to obtain the ordinates, in fractions of an inch. The following is a comparison of the results :—

	Theory.	inch.	Experiment.	inch.
At loaded quarter-span, . .	Depression,	$-0{\cdot}107$	Depression,	$-0{\cdot}110$
At half-span, . . .	Rise,	$+0{\cdot}013$	Depression,	$-0{\cdot}010$
At opposite quarter-span, . .	Rise,	$+0{\cdot}093$	Rise,	$+0{\cdot}055$

With a load of 168 lbs. placed at the quarter-span, taking the mean of two experiments as before, we get the following results :—

	Theory.	inch.	Experiment.	inch.
At loaded quarter-span, . .	Depression,	$-0{\cdot}320$	Depression,	$-0{\cdot}320$
At half-span, . . .	Rise,	$+0{\cdot}040$	Depression,	$-0{\cdot}065$
At opposite quarter-span, . .	Rise,	$+0{\cdot}280$	Rise,	$+0{\cdot}170$

In glancing at these figures, an exact correspondence is noticeable

between theory and experiment in the amount of depression at the loaded quarter-span. We must not, however, allow ourselves to be deceived by an identity of result, which arises from a compensation of opposite disturbing causes. It is evident that the form of wave in the model is different from that of the calculated wave; that the centre is depressed instead of rising; and that, while theory gives 0·60 inch as the sum of extreme depression and extreme rise, experiment reduces this sum to 0·49 inch.

One element of this difference is to be sought for in the stretching of the chain in the model, which causes a deflection at the centre of the girder, and elongates and deepens the wave of depression, at the same time that it reduces the wave of elevation. The other element of difference lies in the resistance of the chain itself to a change of position, a resistance very noticeable in a heavily-weighted model with an exaggerated wave, but omitted in our theory; the error involved in the omission being one on the safe side. The operation of this cause in modifying and reducing the total wave (as measured from extreme deflection at one-quarter span to extreme elevation at the opposite quarter-span) may be traced in the successive experiments made by Mr. Barlow, in which the distributed load on the platform was gradually increased to 193 lbs. In this set of experiments, the girder was a plank, $7\frac{1}{2}$ ins. by $\frac{3}{4}$ in., the deflection of which, without the chain, was 1·48 ins. with 10 lbs. A weight of 56 lbs. was placed at quarter-span from the high tower. The displacements according to theory, after correction for the unequal height of the towers, should be as follows:—

	inch.
At quarter from high tower, . . .	— 0·496
At half " . .	+ 0·148
At three-quarters " . . .	+ 0·540

The actual displacements with no distributed load on the platform were,

	inch.
At quarter from high tower, . . .	— 0·48
At half " . .	— 0·02
At three-quarters " . . .	+ 0·29

But with a distributed load of 193 lbs. placed on the girder, the displacements caused by the 56 lb. weight became reduced to the following:—

	inch.
At quarter from high tower, . .	— 0·31
At half " . . .	+ 0·05
At three-quarters " . .	+ 0·20

As might have been expected, the more the wave is magnified in the model, by reducing the rigidity of the girder, the more widely the actual displacements differ from those of theory; owing to the resistance of the chain to these exaggerated displacements becoming more appreciable. Thus, for the girder which deflected without the chains 2·375 ins. under a load of 8 lbs., if we take a mean between the results given by 56 lbs. placed at one-fourth from the high tower,

and the same weight placed at one-fourth from the low tower, we find the calculated and the actual displacements to be respectively as follows:—

	Theory. inch.	Experiment. inch.
At loaded quarter-span, . .	— 1·108	— 0·855
At half-span, . .	+ 0·138	+ 0·160
At opposite quarter-span, . .	+ 0·971	+ 0·780

The result of the experiments in this instance is very diverse from those of the preceding experiments, especially in the proportionate largeness of the wave of elevation, which in fact seems anomalous.

On the whole, the comparison of these experiments with the results of calculation considerably confirms the accuracy of the theoretical formula, as applied to the small actual displacements of a full-sized bridge. It must, however, be remembered, that it has been assumed that the flexibility of the girder is everywhere uniform, and the same for upward as for downward pressure—conditions not always found in a plank, such as took the place of a girder in Mr. Barlow's model; and assumed, further, that the girder is not continued nor weighted for any distance beyond the face of the piers.

According to the calculated co-efficients, a concentrated load at quarter-span from one tower will cause a depression of 0·0666, or $\frac{1}{15}$th the deflection which the same load without the chains would cause if placed at the centre of the girder. This depression will be accompanied by a rise at the opposite quarter-span of 0·0584. The depression will be increased, and the rise diminished, by the stretching of the chains. The sum, which will not be affected by the stretching of the chains, is 0·1250, or $\frac{1}{8}$th.

(To be Continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

Ancient Standard of the British Inch. By John Taylor.

From the Lond. Athenæum, June, 1860.

Sir John Herschel remarks, in the *Athenæum* of April 28th, that the British inch puts us in easy possession of "a modular system, which might be decimalized, and which, abstractedly considered, is more scientific in its origin, and, numerically, very far more accurate than the metrical system of our French neighbors."

I rejoice at this communication. It has saved our country from the introduction of the French metre, and from the admission of its superiority to our own measures, which, there is reason to believe, have been preserved, without any deviation from the standard, for about four thousand years.

The British inch had its origin, as I contend, in the measurement of the earth made by the founders of the Great Pyramid. They determined, with great exactness, the proportion which the diameter of a

circle bears to its circumference, and having ascertained the measure of the circumference of the earth, supposing it to be a perfect sphere, they divided the diameter into 500,000,000 of units, which we call inches. This appears to have been the origin of our inch. The *polar* diameter of the earth, according to Mr. Airy's calculation, is equal to 500,491,440 of these inches, which measure so little exceeds the mean diameter of the earth, according to the ancients, as to require the addition of only one-thousandth part, to render it, with all but mathematical precision, the 500-millionth part of the earth's axis of rotation.

Sir John Herschel says, that his attention was drawn in the first instance to this *rapprochement* by my statement, that the diameter of the earth, in the latitude of the Pyramid, is 500,000,000 of English inches; "which it is not:" and he adds, "It is singular that the reduction of Mr. Airy's polar axis from feet to inches, in p. 87, which is rightly performed, does not appear to have suggested the least misgiving as to the correctness of the statement." It appears to me that Sir John has misapprehended my meaning. My reference is to the *ancient* measure, and not to the *modern*—to the *mean* diameter, as it was then supposed, and not to the *polar*, as it is now estimated. I fear, however, that by my inadvertence in writing "average" for "polar," at p. 87, when I was comparing the modern diameter with the ancient, I have caused this misapprehension. He is surprised also that I did not "notice the important practical facility of reduction from the parliamentary to the modular standard." But this was not within my province. The proposal of a modular inch comes with great propriety from Sir John Herschel; and, having his recommendation, it will no doubt be adopted by scientific men, in those cases which require its use. The parliamentary inch will still be our measure for all practical purposes.

I agree with Sir John Herschel, that the founders of the Great Pyramid were not likely to be in possession of any *calculus* by which they could determine the true ratio which the circumference of a circle bears to its diameter, so as to be able to represent it with mathematical accuracy, in the proportion which the periphery of the base of the Great Pyramid bears to its radius. They were guided probably in their proceedings, by those general principles which would influence men of common sense. Hence, they may have supposed that if a Pyramid of a certain angle (51° 51′ 14″) had the property of representing the proportion which the radius of a circle bears to its circumference; and a Pyramid of another angle (51° 49′ 46″) had the property of representing the proportion which the square of its height bears to the content of one of its triangular faces; then a Pyramid of an angle between the two (51° 50′ for instance) might combine the two properties so nearly, as to make them think they could embody both results in one structure. They were completely mistaken in this conclusion, since what may be affirmed of the one angle cannot be affirmed of the other; but for want of a calculus they might not be aware of this impossibility.

An evident error in Herodotus led me to observe, with a view to its

correction, that the *square* of the height (though not the *height*) would be so nearly equal to the content of one of the sloping triangles, as to render it probable that the true reading of the passage might be found in this correction. Sir John Herschel approves of the suggestion. He says, "This is the characteristic relation which Herodotus distinctly tells us it was the intention of its builders that it should embody, and which we now know that it did embody, in a manner quite as creditable to their workmanship as the solution of such a problem was to their geometry. This problem, however, has no relation to that of the rectification of the circle." Certainly not. It is gratifying to me, that my conjectural emendation should be allowed to have restored the true reading with so much apparent certainty, after it had been so long lost to the world.

At the close of his communication, Sir John Herschel does me the favor to notice "another curious and novel relation" which I had pointed out at page 37 of "The Great Pyramid," and which "is interesting," he says, "as offering the only tolerable approach in round numbers to an arithmetical relation between any of the dimensions of this Pyramid and those of the earth." But in the *Athenæum* of May 5, he observes, "There is another and a remarkable one which I do not find noticed by Mr. Taylor." If he will refer to pp. 26 and 27, he will see that I have not overlooked it. In correcting the error of Eratosthenes (that the circumference of the earth is equal to 31,500 Roman miles), I say that it is equal to 27,000 miles, and that the tenth of a Roman mile is the height of the Pyramid, including the casing, and supposed to terminate in a point. Thus it is one-270,000th part of the earth's circumference, as Sir John Herschel has stated.

Leonard Place, Kensington, May 29.

The use of Ozone for Cleaning Books, Removing Ink, &c.

From the Lond. Mechanics' Magazine, July, 1861.

Gorup-Besanez* recommends the use of ozone for cleaning and restoring the coloring of old spotted and soiled books and prints. Ozone completely removes writing ink; but printing ink is not attacked by it, at any rate to no perceptible extent; grease spots and mineral colors also remain unchanged, but vegetable colors are completely removed. The method used is as follows:—The air in a sulphuric acid carboy is ozonized by Schönbein's method, which consists in placing in it a piece of phosphorus three inches long and half an inch thick, and pouring into the carboy as much water at 30° C. as will half cover the phosphorus; the carboy is loosely corked and allowed to stand in a moderately warm place until the air is charged with ozone, which generally requires from twelve to eighteen hours. Without removing the phosphorus and water, the article to be bleached is uniformly moistened with distilled water, and after being rolled up is suspended by a platinum wire in about the centre of the carboy. The roll of paper is soon seen to be continually surrounded by the

* Liebig's *Annalen*, May, 1861.

column of vapor rising from the surface of the phosphorus. The time required for the bleaching depends on the nature of the substance, but never requires more than three days; paper brown with age, and colored with coffee spots, in two days was quite white and clean. If the paper were now dried, it would not only be very brittle, but would also rapidly become brown; hence the acid must be completely removed. The paper is immersed in water, which is frequently renewed, until it only gives a very feeble acid reaction with litmus. It is next placed in water to which a few drops of soda have been added, and then, being spread on a piece of glass and placed in an inclined position, is exposed to a thin stream of water for twenty-four hours. After being allowed to stand till nearly dry, it is carefully removed, and dried between blotting-paper. Gorup-Besanez found that ozone was not well adapted for cleaning oil colors.

A new mode of Obtaining a Blast of very High Temperature in the Manufacture of Iron. By Mr. E. Cowper.

From the Lond. Athenæum, July, 1860.

Mr. E. Cowper read a paper descriptive of "A New mode of obtaining a blast of a very High Temperature in the Manufacture of Iron." The blast is obtained by an adaptation of the principle of Siemens's regenerative furnaces. A hot blast of a temperature of 2000° Fahr. can readily be obtained, and this without the destruction of iron tubes —the substance used in contact with the air being the most refractory fire-brick. This mode of obtaining a blast was in successful operation at Messrs. Cochran's iron-works. The temperature of the blast could be regulated to any required degree. The heat might be obtained from the combustion of the waste gases of the furnaces, and with greater economy than by any method hitherto known for economizing these gases.

Proceedings of the British Association.

For the Journal of the Franklin Institute.

Resistance of Wrought Iron Tubes to External and Internal Pressure. Deduced from Experiments of W. Fairbairn.

By Chas. H. Haswell, C. E.

No. 1.

In order to save space and to increase the generative powers of boilers, internal flues and tubes have been generally adopted, and without sufficient attention to the proportions of their diameter, length, and thickness of plates, so as to insure safety, and economy of material in its judicious distribution. Hitherto it has been considered a rule among engineers, that a cylindrical tube, such as a boiler flue, when subjected to a uniform external pressure, was equally strong in every part, and that the length did not affect the strength of a tube so placed. Although this rule may be true when applied to tubes of indefinite lengths, it is very far from true where the lengths are restricted within certain apparently constant limits, and where the ends are securely

fastened, as in heads or tube sheets, which prevent their yielding to an external force, or where, as in flues constructed in courses, the laps present a ring which greatly increases their resistance.

In some experimental tests to prove the efficiency of large boilers, it was ascertained that flues 35 feet long were distorted with considerably less force than others of a similar construction 25 feet long. This result led to further inquiry, and the following series of experiments were instituted, with very conclusive results:

Results *of Experiments on the Resistance of Wrought Iron Tubes and Flues to External Pressure or Collapse.*

Welded Tubes, and Ends Secured to Head Plates.

No. of experiment.	Diameter.	Length.	Thickness of plates.	Pressure of collapse per sq. inch.	No. of experiment.	Diameter.	Length.	Thickness of plates.	Pressure of collapse per sq. inch.
	Ins.	Ins.	Ins.	lbs.		Ins.	Ins.	Ins.	lbs.
1	4	19	·043	170	11	6	30	·043	65
2	4	19	·043	137	12	8	30	·043	39
3	4	40	·043	65	13	8	39	·043	32
4	4	38	·043	65	14	8	40	·043	31
5	4	60	·043	43	15	10	50	·043	19
6	4	19	·043	140	16	10	30	·043	33
7	6	30	·043	48	17	12·2	58·5	·043	11·0
8	6	29	·043	47	18	12	60	·043	12·5
9	6	59	·043	32	19	12	30	·043	22
10	6	30	·043	52					

Riveted Tubes.					*Welded Tubes. Ends left open.*					*Riveted Flues. Ends closed.*				
No. of exp't.	Diameter.	Length.	Thickness of plates.	Pressure of collapse per sq. inch.	No. of exp't.	Diameter.	Length.	Thickness of plates.	Pressure of collapse per sq. inch.	No. of exp't.	Diameter.	Length.	Thickness of plates.	Pressure of collapse per sq. inch.
	Ins.	Ins.	Ins.	lbs.		Ins.	Ins.	Ins	lbs.		Ins.	Ins.	Ins.	lbs.
20	18·75	61	·25	420	23	4	60	·043	47	26	14·5 by 14·6875	60	·125	125
21	9	37	·14	262	24	4	30	·043	93					
22	9	37	·14	578	25	4	15	·043	147					

Cylindrical and Elliptical Riveted Flues.

No. of experiments.	Flues.	Diameter.	Length.	Thickness of plates.	Pressure of collapse per sq. inch.
		Ins.	Ins.	Ins.	lbs.
27	Cylindrical,	18·75	61	·25	420
28	do.	12·	60	·043	12·5
29	Elliptical,	20·75 × 15·5	61	·25	127·5
30	do.	14· × 10·25	60	·043	6·5

Tubes and Short Flues.

In the subjection of a tube or flue to external pressure, the material being compressed, becomes crumpled in longitudinal lines near the middle; the tube loses its original cylindrical shape at and near to that part, whilst the portions toward the extremities when supported by inflexible end plates, or the centre portions when sustained by the laps of the courses, retain their original form; so that the material virtually resisting compression is the comparatively small portion in the middle when the flue is of one course, or in the middle of each course when there are some two to four of them, and which, in the latter case, to a certain extent, is independent of the length of the tube, whilst the pressure producing the compression is always approximately proportioned to the area of the longitudinal section of the tube.

Hence, as the total external pressure on a tube or flue varies directly as its longitudinal section, that is, as the product of the length and the diameter.

$P'\, l\, d\, C = P$. P' *representing the pressure to which the tube is subjected in pounds per square inch; l the length of the tube in feet; and* C *a constant to be determined.*

It has been ascertained by experiment, that the resistance of thin metal plates to a force tending to crush or to crumple them, varies directly as a certain power (x) of their thickness, the number indicating the power lying between 2 and 3.

Hence, the *Value* of a tube, &c., to resist collapse is as $\frac{P}{t^x}$; t *representing the thickness of the metal in inches.*

The mean of the product of $P'\, l\, d$ in the several experiments here given where the metal is of a uniform thickness of ·043 in., is 850, for a thickness of ·125 in., 9140, &c., &c., and the mean of the value of x for all thicknesses is 2·19.

Consequently, $\frac{850}{\cdot043^{2\cdot19}} = 835800$, and $835800 \times \frac{t^{2\cdot19}}{l\, d} = P'$, which is the general formula for calculating the strength of wrought iron tubes and short flues subjected to external pressure within the limits indicated by the experiment; that is, provided their length is not less than 1·5 feet, and not greater probably than 10 feet.

In order to facilitate calculation, this formula may be written,

$$\log. P = 1\cdot5265 + 2\cdot19 \log. 100\, k - \log. (l\, d):$$

and by an obvious transformation,

$$\frac{850}{l\,.\,d} = P'.$$

By taking 2 instead of 2·19 for the index of t, this formula becomes as follows:

$$V \times \frac{t^2}{l\, d} = P', \textit{ the collapsing pressure.}$$

For thick tubes of considerable diameter and length, this formula is sufficiently exact for practical purposes.

V varies with the thickness of the tubes and flues, and may be safely estimated as in the following table:

When a Flue is constructed of courses, the above rule will apply by estimating the length of it to be the distance between the centres of two contiguous laps, if the whole length of the flue does not exceed three times the length of a course; when, however, the length does exceed that proportion, the estimate of its resistance is to be made by taking the units from the following tables:

In one experiment, the tube was divided into three parts by two rigid rings soldered upon its exterior, and its powers of resistance were thus increased in the ratio of three to one; *virtually*, the length was reduced in this ratio, and the strength was *actually* increased from 43 to 140 lbs. per square inch.

		For Lengths from 1·5 to 10 Feet.				
From ·043	to ·125	inch in thickness,	380,000	to	520,000.
·125	" ·250	" "	520,000	"	650,000.
·250	" ·375	" "	650.000	"	720.000.
·375	" ·500	" "	720,000	"	800,000.
		For Lengths from 10 to 18 Feet.			
From ·125	to ·250	inch in thickness,	650,000	to	720,000.
·250	" ·375	" "	720,000	"	810,000.
·375	" ·500	" "	810,000	"	910,000.
		For Lengths from 18 to 25 Feet.			
From ·125	to ·250	inch in thickness,	720,000	to	810,000.
·250	" ·375	" "	810,000	"	920,000.
·375	" ·500	" "	920,000	"	1,020,000.
		For Lengths from 25 to 35 Feet.			
From ·125	to ·250	inch in thickness,	810,000	to	920,000.
·250	" ·375	" "	920,000	"	1,020,000.
·375	" ·500	" "	1,020,000	"	1,120,000.

NOTE.—In selecting the above units, regard should be had to the length of the flue, independent of the ordinary conditions of strength of the materials, and character of the riveting; as the nearer the length is to the limit of the length at the head of each table, the higher the unit is to be taken.

Illustrations.—1. Let $t = \cdot 043$ in., $l = 2\cdot 5$ feet, and $d = 6$ ins.

Then, $\frac{\cdot 043^2}{2\cdot 5 \times 6} \times 400{,}000 = \frac{\cdot 001849}{15} \times 400{,}000 = 49\cdot 3$ *lbs.*

Experiments 7 and 10 give 50 *lbs.* for a length of but 2·5 feet.

2. Let $t = \cdot 25$ in., $l = 5$ feet, and $d = 18\cdot 75$ ins.

Then, $\frac{\cdot 25^2}{5 \times 18\cdot 75} \times 585{,}000 = 390$ *lbs.*

Experiment 20 gave 420 *lbs.* for a length of but 5 feet 1 inch.

3. Let $t = \cdot 375$ in., $l = 25$ feet, and $d = 42$ ins.

Then, $\frac{375^2}{25 \times 42} \times 920{,}000 = 123\cdot 2$ *lbs.*

An experiment gave 127 *lbs.* for a length of 25 feet.

The following table will show how nearly this formula represents the results of the experiments on the different classes of tubes:

No. of experiment.	d Diameter.	l Length.	t Thickness.	P′ By experiment per sq. in.	P′ By formula of $t^{2\cdot19}$.	P′ By formula of t^2.
	Ins.	Feet.	Ins.	lbs.		
2	4	1·58	·043	137	130	130
5	4	5	·043	43	41	41
7, 10, 11	6	2·5	·043	55	54·7	54·7
13	8	3·25	·043	32	31·6	31·6
15	10	4·16	·043	19	19·7	19·5
18	12	5	·043	12·5	13·6	13·6
20	18·75	5·08	·250	420	407	435·5
21	9	3·08	·140	378	392	388·3
26	14·6	5	·125	125	116	134·7

RESULTS *of Experiments on the Resistance of Wrought Iron Cylindrical Tubes or Flues to Internal Pressure or Bursting.*

Number.	Diameter.	Length.	Thickness.	Pressure of rupture per sq. in.	REMARKS.
	Ins.	Ins.	Ins.	lbs.	
31	6	12	·043	475	Burst by rending of rivets.
32	6	24	·043	235	Burst through plates and rivets; plates very brittle.
33	6	30	·043	230	Burst by rupture of rivet-heads.
34	6	48	·043	375	Burst by rending of rivets.
35	12·13	60	·043	110	Burst through plates and rivets; plates brittle.

Formulæ of Resistance of Cylindrical Tubes or Flues.

The strain which the material of a cylindrical vessel is submitted to, when a uniformly-distributed external pressure is applied to it, is very different from the strain produced when the pressure acts internally. In the latter case the material is equally extended throughout all its parts, and its cylindrical form is preserved at all stages of the pressure, with the exception of the small portion of the plates when they overlap to close the extremities. The tube under a high internal pressure will assume the form of the middle frustrum of a spindle, and the relation of the force of rupture to that of resistance will be approximately expressed by

$$\frac{2\,\mathrm{T} \times t}{d} = \mathrm{P}.$$

T *representing the tensile resistance of the material per square inch in pounds, t its thickness, d its diameter in inches, and* P *the pressure requisite to produce rupture of the tube, or flue, in pounds.*

From a consideration of which experiments, it appears—

1st. That the resistance of Tubes or Flues to an External or Internal Pressure, varies directly and inversely as their diameters.

2d. That the resistance of a Tube or Flue to External Pressure up to the lengths experimented upon, is inversely as its length. Consequently, the resistance of tubes or flues to external pressure, of different diameters, but of equal lengths, varies inversely as their diameter, and contrariwise.

3d. The Tubes or Flues, with lap-joints, have one-third less resistance to external pressure, than when their joints are abutted.

4th. That a Cylindrical Tube or Flue has three times the resistance to external pressure of an Elliptical tube or flue, of the proportionate diameter given in the experiment noticed (29).

5th. That the length of Tubes or Flues, to resist Internal pressure, has no essential effect.

6th. That with Tubes or Flues of like thickness, their resistance varies inversely as the product of their lengths by their diameters.

Results of Experiments on the Resistance of Elliptical Flues to External Pressure or Collapse.

By comparing the result of Experiment (30) on the elliptical tube with the result of the experiments on the cylindrical tubes, we find that the preceding general formula will apply approximately to elliptical tubes, by substituting for d in that formula, the diameter of the circle of curvature touching the extremity of the minor axis. *Thus:*

$$\text{Diameter of the circle of curvature} = \frac{2\,r^2}{r'} = \frac{2 \times 7^2}{5{\cdot}125} = 19{\cdot}12 \; ins.$$

The pressure on this elliptical tube was 6·5 *lbs.*, which reduced to unity of length and diameter, = 621·4 *lbs.* (19·12 × 5 × 6·5), which result nearly agrees with 688 *lbs.*, the mean pressure of the 12-inch tubes also reduced to unity of length and diameter.

The pressure P′ per square inch, requisite to collapse a tube of variable curvature, varies inversely as the diameters of curvature.

(To be Continued.)

Notice respecting certain Phenomena of Crystallization and Polarization in Decomposed Glass. By Sir D. BREWSTER.

From the Lond. Athenæum, July, 1860.

At the meeting of the British Association held in Aberdeen, the author read a paper "On the Decomposed Glass found at Nineveh, Rome, and other localities," but not then having any drawings to exhibit to the Section, he found it difficult to convey an intelligible account of the structure and remarkable phenomena which the specimens exhibited both in common and polarized light. He now exhibited and explained very beautifully-executed colored drawings and diagrams explanatory of these appearances and properties. In this paper he omitted all reference to those colorless specimens by which he had then shown that a bundle or pile of these transparent films act upon

common and polarized light as negative uniaxal crystals, producing all the colors of polarized light, by the interference of two oppositely polarized pencils, one of which is the transmitted light, the other a combination of all the pencils reflected from the anterior surfaces of the films. He then pointed out the difference between artificial glasses and naturally-formed crystals, like rock crystal. In the glasses the atoms are forced, by melting them at high temperatures, to unite by chemical affinity. In the others the particles have united by peculiar polar actions while crystallizing naturally. Hence, the atoms of crystals being simple and similarly united throughout the entire crystal, have no tendency to decompose or reunite in other forms at particular parts; but the forces by which the earths, alkalies, and metals are composed, not being uniformly arranged as to the forces by which the different parts are held together, tend to separate and reunite in new or more natural crystalline relations in relation to particular points, lines, or surfaces in their mass. Thus the rock-crystal lens found by Mr. Layard at Nineveh was as perfect in its structure now as it was many thousand years ago, when in the form of a crystal, while the glass was found altered as in the specimens now shown; and few bodies cease to exist with such grace and beauty as glass, when it surrenders itself to time and not to disease. In stables, where ammonia and other exhalations prevail, and in damp localities, or where acids or alkalies prevail in the soil, the process is more rapid, and it may frequently be broken between the fingers of an infant, sometimes presenting in the middle a plate of unaltered glass, to which the process has not extended; but it is in dry localities, where Roman, Greek, and Assyrian glass has been found, that the process of decomposition is exceedingly interesting, and its results singularly beautiful. At one or more points in the surface of the glass the decomposition begins. It extends round that point in spherical surfaces, so that the first film is a minute hemispherical cup of exceeding thinness. Film after film is formed in a similar manner, till perhaps 20 or 30 are crowded into the 50th of an inch. They there resemble the section of a pearl (or of an onion), and as the films are still glass, the colors of thin plates are seen when we look down through their edges, which form the surface of the glass. These thin edges, however, being exposed to the elements, suffer decomposition. The particles of silex and the other ingredients now readily separate, and the decomposition proceeds downwards in films parallel to the surface of the glass; the crystals of silex forming a white ring and the other ingredients rings of a different color. Such is the process round one point, but the decomposition commences at several points; generally these points lie in lines, so that the circles of decomposition meet one another and form sinuous lines. When there are only two points near, these circles of decomposition surround the two points, like rings round two knots in wood; but when there are many points near, the curves unite and form sinuous lines. When the decomposition is uniform, and the little hemispheres have nearly the same depth, we can separate the upper film from the one below it; the convexities of the one falling into the concavities of the others.

The drawings of these were executed by Miss King, now the Honorable Mrs. Ward. When the decomposition has gone regularly on round a single point, and there is no other change, there is a division of the glass into a number of hemispherical films within one another. The groups of films exhibit in the microscope circular cavities, which, under different circumstances, become elliptical and polygonal. M. Brame, of Paris, succeeded in rapidly producing this decomposition by immersing glass in a mixture of fluoride of calcium and concentrated sulphuric acid, or by exposing it to the vapor of fluohydric acid.—(*Comptes-Rendus*, Nov. 2, 1852.) The author then went on, and with the diagrams explained the optical phenomena, grouping them into three chief varieties, but stating them to be so various and singular as to baffle description:—First, of those which have rough surfaces: these form an almost infinite number of hemispherical cavities on one side of the film, and similar convexities on the other. These are perfectly circular when separated by flat portions of the film; but when crowded together they are irregularly polygonal, the polygons forming a sort of network, the concave and convex surfaces not being rough, but specular, reflecting and transmitting white light, and exhibiting none of the colors of thin plates, but in polarized light acting as uniaxal crystals. Secondly, The second variety have perfectly specular surfaces, in consequence of having almost no cavities, in common light exhibiting in a very beautiful manner the colors of thin plates, the transmitted complementary to the reflected light. This variety is exceedingly rare. The specimen on the table showed blue as the reflected and yellow as the transmitted light. In some of the fragments a few insulated circular cavities with the black cross occurred, modified as to tints by the general tint of thin plates. Thirdly, The third variety consists of films containing cavities of all sizes and forms, from the thirtieth of an inch to such a size that they are hardly visible in the microscope, giving to the film a sort of stippled appearance. Their cavities are circular, elliptical, or irregularly polygonal, and they reflect and transmit complementary colors, some showing the black cross, though varied in its shape. The cavities are often arranged in sinuous lines, and encroach on one another. They frequently run in perfectly straight lines, and when very small and invisible as cavities, their margins form in polarized light brilliant lines, often grouped in bands like the stripes in ribbon; they are but a few thousandths of an inch in diameter, and might be used as micrometers in the microscope. These lines of polarized light all disappear when they lie in the plane of polarization of the incident light or perpendicular to that plane. Many other optical circumstances connected with this variety were mentioned by the author and explained. In all these three varieties the films are pure glass, for they become colorless by a sufficient inclination of the plates, and also by introducing a drop of water or alcohol, which, when it evaporates, allows the original colors again to be recovered, and although a film of the fluid separated each of the almost infinitesimal layers of the glass, yet they afterwards adhere as firmly as ever. If an oil or balsam be introduced, it slowly and un-

equally passes between the layers, so that the retreating color is bounded by a stratum of the various tints which the film combines. But the author has often found between the true glass films beautiful circular crystals of silex, finely seen in polarized light. These are sometimes dendritic, and assume, round the black cross, foliated shapes. One form merits particular attention: around a minute speck of silex there is formed a circular band of equally minute crystalline specks, and at a greater distance a second circular band concentric with the first, consisting of still smaller siliceous particles hardly visible in the microscope. By what atomic forces does this central crystal group its attendant crystals around it?

Mr. Stoney observed that Dr. Lloyd, at the Aberdeen Meeting, had shown that the light from these specimens of decomposed glass, exhibited by Sir D. Brewster, was elliptically polarized, and that therefore they must behave like uniaxal crystals.

Proceed. British Asso. for Adv. of Science.

On Fresh Water Wells near the Sea Coast.

From the London Athenæum, August, 1860.

Sir Emerson Tennent notices the fact of all the wells along shore which keep their water during the dry season, being below high-water mark, and that, to a small extent, they rise and fall with the tides; and he assumes that they owe their water to the sea, which loses its saline matter by percolation. Nothing, surely, is more utterly opposed to the first principles of Physics than the doctrine that salt held in chemical solution by water should be capable of being separated from it by the mechanical process of filtration. The phenomenon of tides in wells of moderate depth dug near the sea is of universal occurrence all along the Malabar coast, where the matter dug through is porous. It does not obtain in wells dug through trap. I have observed it hundreds of times at Bombay, and have often had occasion to describe it. The explanation is easy. The surface of the ground where the well is dug being always six or eight feet above high and twenty to twenty-six feet above low water, and being extremely spongy and porous down to where it comes in contact with the rock, or the blue clay bed which commonly lies over the rock, it gets charged full of the water during the rains. The superior length of column enables this to expel the sea water, a proceeding which must have been completed shortly after the emergence of the land from the sea; while the interstices in the porous soil are so minute as to prevent the two mingling. As the saltest sea water has only a specific gravity of 1·050, the fresh water ponded back from it requires only to be proportionally higher in level to create an equilibrium. With a greater head than this, it will push the wall of salt water before it, and flow off. Of all this, I have seen abundant examples at Bombay. It would occupy too much of your space to describe them. After six or eight months of rainless weather, when the discharge from the soil becomes feeble, the wells all become more or less brackish, and the apparent tide increases.

The *Edinburgh Review* states, that this theory of Sir E. Tennent, of the desalinization of sea water by filtration (as already said, a phenomenon opposed to one of the first laws of chemistry), explains the occurrence of fresh water on coral islands, and confutes the theory of Darwin, that this arises from rain, as rain falling on a substance already fully saturated with sea water would not be absorbed, but would flow off. Not a doubt of it. But coral islands are not only not saturated, but so much of them as is above the sea level three or four feet is highly porous and perfectly dry, and presents all the conditions for absorbing the whole of the rain that falls on them. They present to the rain this much head of water to push out the sea and expel it piston-wise so far as the coral bed descends—the sea itself forming the wall of the reservoir. A well dug deep into the coral to draw off the rain water, with which it is always nearly saturated up to low water mark, is sure to secure a supply. An illustration of the two not mixing together, if the pores of the soil, rock, or coral, be fine enough, may be obtained by making the experiment with capillary tubes.

For the Journal of the Franklin Institute.

The Expansion of Water NOT *an Anomaly in the Solidification of Liquids.*

In the article on expansion in that valuable work, the "New American Cyclopædia," reference is made to the dilatation of water when cooled down to near the freezing point, and to the beneficent effect of ice being thus caused to float, instead of sinking and choking up our rivers. The fact is mentioned, as it has long been mentioned in the books, as a remarkable exception to the general law of expansion of liquids in proportion as they are heated. Thus, Arnott, in his Physics, designates it as "a most extraordinary exception to the law of expansion by heat and contraction by cold," producing unspeakable benefits in nature, &c.

In Brande's Dictionary of Science it is said, "In general, all liquids expand and contract in proportion as they are heated and cooled, but to this law there is a remarkable and anomalous exception in regard to water."

According to the latest edition of the Penny Cyclopædia, "Water, like all other fluids and substances, expands by exposure to an increase of temperature, and, with a curious exception, the dilatation within certain limits is proportionate to the degree of heat to which it is subjected. It is, however, found that water, a few degrees above its freezing point, is more dense than exactly at it."

Jamieson, in his Dictionary of Mechanical Science, after stating that there are cases in which expansion is produced not by an increase but by a diminution of temperature, adds, "Water furnishes us with the most remarkable example of the kind." Dr. Draper, in his Text Book of Natural Philosophy, observes that solids and liquids do not expand with regularity, and that "there are special irregularities of which water is an example."

"Water is wisely ordained by God to be an exception to a very general law—it contracts till it is reduced to 42°, and then it expands till it freezes."—Guide to Scientific Knowledge, by Rev. Dr. Brewer of Trinity Hall, Cambridge. American ed., 1851.

In Kemp's Phases of Matter, Lon. 1855, we are told, "There is a most remarkable exception to this law of expansion in the case of water. Ice, as every one knows, swims upon water, and of course is lighter; * * that is to say, heat does not expand ice, but, on the contrary, contracts it. * * Whatever may be the cause, it is one of the most striking instances of design that can be witnessed in nature; and, were it not for it, the globe would scarcely be habitable by man. * * Did water obey the usual law in this respect, it would fall to the bottom as fast as formed."

"In freezing, there are some peculiar conditions connected with water. This fluid is at its maximum density at 40° of Fahrenheit; in cooling further, an apparent expansion takes place, and water cooler than this floats on the warmer fluid. This may, I think, be explained without that mysterious alteration of a fixed law which is sometimes had recourse to as a means of explanation. Water in cooling below this point, commences an arrangement of its particles preparatory to their passing into the solid form, different from that which previously obtained; the grouping of the molecules partakes of an angular rather than that of a spherical character, and hence in one direction they occupy more space," &c. Elementary Physics, by Robt. Hunt, Lon. 1855.

Considering the progress of science down to the close of the 18th century and its still further advances to the present day, it is singular that this alleged anomaly should have been so long taken for granted and stereotyped in works on Natural Philosophy. It is many years since it was questioned here by some members of the Mechanics Institute, because of its inconsistency with facts familiar to them. It was stated that it presented no "remarkable," "peculiar," "curious," "extraordinary," or "anomalous" exception, nor any exception at all to any law, but was in strict accordance with the one that governs the solidification of liquids—that if ice did not float, the fact would be an anomaly.

It was affirmed that, if our lakes and rivers were fluid metals, with their surfaces congealed in winter, the solid portions would swim as ice swims; and the proofs offered were that pigs of lead and tin float in liquid lead and tin, and that the like takes place with gold and silver, zinc, copper, and iron, as may be daily witnessed in the factories. The inference seemed to be that most, if not all, solids are less dense than are their liquids at certain temperatures, and those who doubted this were asked to name a liquid, either vegetable, animal, mineral, or metallic, in which portions solidified do not swim. Wax, pitch, rosin, fat, sugar, sulphur, and other substances, were named as affording no support of the common doctrine.

In passing into the solid state, the molecules of every liquid assume an arrangement more or less peculiar to it, and, as this must take

effect at some point of the decreasing temperature, it matters not where that point is as respects the common law of expansion. It no more affects that law than the journey of a traveler is affected by his stopping a moment to exchange a word with a friend. It neither affects his previous nor his subsequent progress—has, in fact, nothing to do with either.

The temperature of solidification of course differs in different substances, and so does the effect. It is the molecular arrangement that diversifies the crystalline structures, and consequently the properties of solids; that gives to each a "grain" and character peculiar to itself. In the soft metals, the crystalline texture would hardly be suspected, but it may be vividly brought out, even in lead, by crushing a mass just before solidification is completed. In iron foundries, the moment when the crystals are forming is often indicated by a rising of the metal in the gates of a mould.

It is known that the crystalline structure of metals is deranged by rolling, stamping, forging, wire-drawing, and other processes, but it is not commonly known that this effect is temporary, that they have power within themselves to recover their pristine formation. This we have noticed in drawn wire and pipes of block tin. When of pure metal, they are soft almost as lead, and yield to flexure as silently; but if laid aside a few years, they give out when bent the crackling noise by which bars of the metal are characterized.

A very interesting fact is mentioned by Scoresby. He found in the Arctic regions that water congeals there in an almost endless variety of geometrical figures, of which he enumerates five classes—the lamellar, the stelliform (which is most general, and occurs chiefly when the temperature is near 32°), the regular hexagon (which becomes thin and diminishes in size as the cold increases), aggregates of hexagons, which occur chiefly at low temperatures, and, lastly, combinations of hexagons with spines or radii.—Arctic Regions, vol. 1, p. 432.

That this change of structure occurs in the metals, is exceedingly probable, and that upon it the tempering of steel depends. We know that its different degrees of hardness arise from the different temperatures at which it is cooled—that is, from changes in the form of its crystals.

There is another point of resemblance between liquefied metals and water, which has not found a place in text books, though published by the Messrs. Appleton nearly twenty years ago, in Ewbank's Hydraulics, viz: capillary action.

*

New York, September 16, 1861.

Large Casting.—An enormous casting has been made in the foundry of Messrs. R. and G. Harris, of Rotherham. The total weight of the casting is 33 tons 10 cwt., and it is to form a bed for an immense hammer at the new works of Messrs. John Brown & Co., Sheffield. The metal was run from the cupolas in four minutes and a half.—*Builder.*

For the Journal of the Franklin Institute.

On the Erie Experiments on Steam Expansion by U. S. Naval Engineers. By Samuel McElroy, C. E.

(Continued from page 237.)

When we examine another very important detail of method adopted in these experiments, viz: as to the measurement of coal consumed, we find it also inaccurate and unsatisfactory. This the printed explanation makes sufficiently plain; for when we are told that the notes for each experiment were commenced "with average fires" in the boilers, and that the fires were made at the close, "the same as at the beginning, *as nearly as could be estimated*," we understand at once that the Board only weighed what coal was used during the actual term of any trial, and *guessed* at the state of the boilers at its commencement and end. The precise quantity of coal which produced the recorded number of engine strokes was not *weighed*. For that essential particular, the Board asks us to accept its estimate, and this admission is in itself fatal to any claim of accuracy otherwise presented. Anybody can guess, but it belongs to experimenting engineers to measure and rigidly determine every detail, and especially so important a detail as the coal account, on which all the calculations of results depend. So long as it is easy to determine this account in experiments of this class, beyond any question, we are not prepared to accept any explanation or any apology for its omission. Those who have had frequent occasion to probe these processes, are not to be told that the absolute state of a boiler fire can be determined by its appearance, or its level, or the water level, or the steam gauge; for we know by the results of frequent analyses, that these features may be identical where there is a difference of fifty per cent. in absolute efficiency. Nor can we yield the professional rule in this case, which refuses to accept opinions and estimates where actual quantities are at issue. With the coal account in this state for each experiment, it is impossible for this Board to claim that it has *demonstrated* any thing. In entering voluntarily the field of estimate and conjecture, it submits to the "theoretical considerations" it claims to have overthrown.

Farther, in what way are we to reconcile this assumed process with the 1st and 2d experiments? At the close of the latter, the "average fires" represent a combustion of 3·79 lbs. per square foot of grate, while at its commencement, which also marked the close of the 1st experiment, the rate then represented is 6·28 lbs. per square foot. There can be but one conclusion in a case of this kind, and it is not very creditable to the discretion of this Board in matters of judgment and opinion. Not only is the accuracy of the coal account involved here, but the per centage of ashes, the boiler evaporation, the horse-power, and the resistances.

In experiment No. 5, at $\frac{7}{10}$ths cut-off, the coal account is credited with 18·53 per cent. of refuse, while No. 7, at $\frac{4}{45}$ths cut-off, is credited with but 6·99 per cent., which is not exceeded in any other experiment, none of them agreeing as to this per centage. In No. 5, a different

variety of coal was used from Nos. 1, 2, 4, and 7. But is it to be inferred from all these discrepancies that the coal varied so much in quality, or that the system of measurement was defective in accuracy? Under such circumstances, which is the most likely to be true? Two important conditions of the measurement were guessed at; the third only was determined.

We are disposed to concede to this report the merit of deep and abstruse argument. After looking over it very carefully, when it first came to hand, in some bewilderment as to what it really did assert, we endeavored to find some one place where a clear and unmistakeable conclusion was presented, and failed in discovering any thing more definite than the quotation with which we commenced this paper. But in those brief sentences, strange contradictions occur. They begin by admitting a gain with two-fifths cut-off; they assert a loss at one-quarter, a loss which we might assume to be referred to full travel, if one-sixth was not immediately presented as such measure. And yet, a page or two back, we are told that if "the proper corrections could be made for the difference of cylinder temperature due to the different measures of expansion, it would doubtless be found that the economical result obtained when cutting off at seven-tenths, is not exceeded when cutting off at any less fraction."

It is not an easy matter, therefore, to pass from general questions of principle and method to a discussion of absolute results, so many different ones having been obtained. The general argument of the report is against the use of expansion at all. The summary of all the allowances, assumptions, and equivalents in table No. 2, ranges the "economic result in net horse-power" with $\frac{4}{45}$, $\frac{1}{6}$, $\frac{11}{12}$, $\frac{1}{4}$, $\frac{3}{10}$, $\frac{7}{10}$, $\frac{4}{9}$ths cut-off in order of precedence, while the "economic power" in "pounds of steam per horse-power per hour," ranks them $\frac{4}{9}$, $\frac{7}{10}$, $\frac{3}{10}$, $\frac{1}{4}$, $\frac{11}{12}$, $\frac{1}{6}$, $\frac{4}{45}$ths cut-off, which exactly reverses the order. Precisely what conclusion the Board really reached does not appear in the report; while its argument rejects expansion, its tables confirm it in part, in instances which contradict its explicit assertions.

In table No. 1, the order of results for the "pounds of combustible" per horse-power, is $\frac{1}{4}$, $\frac{4}{9}$, $\frac{7}{10}$, $\frac{3}{10}$, $\frac{1}{6}$, $\frac{11}{12}$, $\frac{4}{45}$ths cut-off.

Passing from this troublesome triangular tabular duel, we may take up the assertion, that "the economy of cutting-off at one-sixth or four-forty-fifths is considerable less than with steam used absolutely without expansion," for the purpose of tracing the argument of the report.

Assuming that the "data" given in our synopsis of table No. 1 were rigidly and accurately obtained, we cannot compare the results of one-sixth cut-off with full steam travel, because the latter was not tested; but taking eleven-twelfths as an approximation, the horse-power per pound of coal is in favor of the former as 5·53 to 4·58, although there is a loss of ·9 inch in vacuum.

In this case, the horse-power is determined by the mean pressure of the indicator cards, the revolutions, and the coal account in the usual way.

But the Board decides the propriety of making certain corrections to these "data."

The per centum of refuse in the coal account varies in each trial. It is as low as 5·75 and as high as 18·53. For one-sixth cut-off it is 5·75, and for eleven-twelfths it is 6·83. The latter is therefore credited with the difference. Having already expressed our opinion of the special accuracy of experiment No. 2, which cuts off at $\frac{1}{6}$th, we need not reiterate obvious objections. It is enough to suggest that if, in experiments as delicately conducted as these, the same boiler work could not be realized in similar kinds of coal, a principle under investigation ought not to be charged with the difference, and also, that it is not perfectly clear that the difference between ashes in weight and that of the coal producing them, represents the absolute evaporative value of the coal. The manner in which the coal is burnt has something to do with that point.

There is a difference of vacuum against No. 2 which we do not find credited.

Experiment No. 7 ($\frac{11}{12}$ths) shows an average back-pressure in the cylinder of 4·2 lbs., while No. 2 shows but 2·8 lbs. In all these trials, it appears that expansion reduces back-pressure by a descending series, except a change in No. 7. But, without accepting this *experimentum crucis* of the condensation argument, the Board decides that back-pressure must be assumed at a common standard, which it accordingly takes at 2·7 lbs. from No. 3. Consequently, the mean pressure of No. 2, which is 13·6 lbs., is to be charged with the standard of 2·7, while that of No. 6, at 29·8 lbs., is credited with the difference between 4·2 and 2·7. This varies the relative horse-power, and is highly creditable to the treatment of the questions at issue.

The Board then enters into a long argument to show that the "net horse-power applied to the water by the paddles" is the only correct basis of calculation of work, rejecting the work which is done by the piston. This involves a difficulty, slight, however, to ingenious men. After the trials are over, they spin the wheels around at various speeds, and determine by indicator cards the exact "pressure due to the friction and resistance" of the organs of the engine, which they establish at the common standard, for all loads and all speeds, of 2·1 lbs. per square inch. The mean pressure of No. 7 bears this charge much more easily than that of No. 2.

In this case, the expansion is charged with the interesting fact that the friction of an engine, and especially an engine paddling water, is constant at all speeds, and under all loads. If the velocity varies in the proportion of 11·17 to 20·61, and the load varies in the proportion of 13·6 to 29·8, the effort is precisely 2·1 lbs. per square inch in each case. It is 15·4 per cent. in one, and 7 in the other. Morin, Weisbach, and others, have therefore been convicted of many "fallacious theories" on this matter of frictional and fluid resistance. Their results are entirely reversed.

And yet, granting all these equivalents, when we reach the last point of calculation, we find that the experimental result in net horse-

power for No. 6 is 1000, and for No. 2 is 1065. It is not true, then, that it is better to cut off at $\frac{11}{12}$ths than at $\frac{1}{6}$th, and, by consequence, it is not true that it is still better to follow full stroke. The summary of the report falls to the ground: *vox et præterea nihil.*

But the economy of full steam, we are told, is comprehended in the use of smaller engines, which are to save first cost, space and repairs. In what respect, except as to the bore of the cylinder, is the *Michigan's* engine to be reduced? The wheels, shaft, cranks, and connexions, condenser, air-pump, &c., at one end must retain their present strength and size, and at the other end the boilers must be as large and require as large coal bunkers. In reducing the bore of the cylinder, it would be improper to reduce the side-pipes and valve-chests, and the piston-stroke should not be shortened. Nothing, then, can be saved, except a few pounds of cast iron, a few bolts, and a little wrought iron and rubber. The modified engine will go to sea like one of the fashionable belles denounced in medical journals: the head, arms, and lower limbs fully developed, but the seat of vital action laced and compressed beyond all reason and contrary to natural health. If the Board holds that the friction of an engine is independent of its load, it may also hold that "wear and tear" is equally independent; otherwise the working parts save nothing in repairs or liability to fracture.

Again, we are informed in the report, that the pressure defined by the law of Mariotte, as derived from "abstract considerations," and illustrated by indicator cards, is "so specious, and apparently so conclusive (as a promise of economy in expansion), that up to within the last one or two years, the assumption passed unchallenged by the engineering profession;" but the Erie experiments claim to have overthrown this specious assumption.

We have analyzed these experiments sufficiently to show that, however improper their *modus operandi*, their results do not prove any loss in power. Let us now examine the theory of a loss which is asserted and not demonstrated.

It is asserted that, in the case of full steam travel, as the piston gradually uncovers the surfaces previously exposed to the exhaust, a condensation takes place; so that, at the end of the stroke, the cylinder surface is covered with a film of water at exactly the boiling-point, due to the pressure of its steam charge. When the exhaust valve now opens, this water evaporates, and the value of its heat is lost in the condenser.

When the cut-off is used, the condensation goes on in the same way, except that the film of water condensed before the valve closes commences to evaporate as the pressure falls, and re-evaporation takes place on the surface of the cylinder throughout the stroke, instead of after the return stroke, cooling down the surface during the whole time of expansion movement. This loss is said to be of a very serious character, and, like that due to full travel, must be made up at every new stroke.

This Board is twice mistaken. First, in assuming that engineers

have depended on realizing the absolute results of Mariotte's law, without the modifications due to conditions of practice; and, second, in assuming the merit of discovering this process of condensation.

The losses due to imperfect combustion and evaporation, foaming, condensation in steam passages, leakage of valves and joints, and back-pressure, certainly have been fully admitted, and are always anticipated. And precisely as far as these may, in practice, modify the results of an absolute law, our confidence in the law itself need not be affected. Imperfections in application, instead of inclining us to this monstrous argument, which would dispense with expansion because some of its benefits are vitiated, should only prompt us to the construction of more perfect machinery, by which the law itself may have a better development. No single portion of this report, no result attained, disproves the correctness of the law, and its whole argument, rightly understood, vindicates expansion against imperfect mechanism, imperfect management, and prejudiced experts.

As long ago as 1782, the master mind of the steam engine, in proposing to cut off at one-quarter, was discussing the effects of this principle of condensation. Since that time, all the way down, engineers have taken ordinary and extraordinary precautions against it. They have built fires under their cylinders, they have placed cylinders within cylinders, they have built around them brick-work houses, they have exhausted the varieties of non-conducting materials, in all kinds of felting and jacketing. There is not any thing new, then, in this discovery of condensation, or the apparently neglected operation of external radiation.

Nor is it true that experiments on the assumed losses by condensation are at all novel. The author of the "Precedents" only provoked a smile when he congratulated himself as the first to compare the *tank* with the *indicator*. The idea is not at all patentable.

Nor is it any thing of a novelty that comparisons between the tank and indicator should, on account of imperceptible boiler waste, foaming, steam-pipe and cylinder condensation, valve leakage, &c., show a per centage of difference depending on the comparative protections used against these losses. Nobody disputes it. Everybody anticipates it.

So fully, in fact, are engineers advised on this point, that when any experiment is presented to them, no matter by whom conducted, which claims to have found but 2·91 per cent. loss between the tank and indicator, they respectfully deny its accuracy: It is impossible to avoid a greater loss in the boiler itself, and between the boiler and steam-chest, and at the valves, as well as in the cylinder. Take the case actually presented. The boiler pressure for experiment No. 6 is 36 lbs. and at the cylinder valve we have 34·9, or a little over 3 per cent. in that item alone. In No. 7, the boiler pressure is 36·9 and the pressure at the valve 34·8 lbs., or 5·7 per cent. less, in this respect alone. No credence whatever, then, can be given to the calculation, which sums up all the losses in $\frac{1}{12}$ths steam travel at 2·91 per cent., finding them for $\frac{4}{45}$ths, 37 per cent. The indicator cards given for experiment

No. 6, show a final pressure of 29·3 lbs., whereas, with an initial pressure of 34·8, it should not have been less than 31·9. Here is a loss of 2·6 lbs. to be accounted for, or about 8 per cent., making a total for but two items of all those in force of 11 per cent., which the indicator cannot show. When we turn to the expansion card of No. 2 and No. 7, on the other hand, we find that the final pressure in the first case is 7·8 lbs., when it should not be over 5·71, being 2·09 lbs., or 37 per cent. in excess; in the second case it is 5·9 lbs. instead of 3·02, being 2·88 lbs., or 95 per cent. in excess. This excess the indicator has accounted for, as well as the tank, but the book-keeping of the Erie Board brings expansion still in debt.

Granting, for the moment, the correctness of the theory of condensation we have quoted, as an argument against expansion, when we come to compare it with the losses due to any condition of operation, what is its practical amount? Expanding or not, at every stroke the cylinder surface is exposed to the action of the exhaust, which must be much more formidable than the action of the steam charge, no matter what its conditions. Whatever this loss may be, is it not true that its effect, after the engine has attained uniform action and after the main valve closes, is confined entirely to the particular charge of steam enclosed by the valve in the cylinder; and, inasmuch as *pressure*, *temperature*, and *volume*, are rigid measures, one of the other, how can it be denied that the indicator is a correct index of all such effects? As the indicator card does not in reality measure the operation of any given stroke on each side of the piston, but combines the steam travel of one stroke with the exhaust travel of the succeeding one, it is also a measure in any special steam travel of the effects of its precursor; and, until it can be proved that the volume and temperature of the steam charge can be changed without affecting its pressure, pressure must be taken as a direct index of each. We have looked in vain through this report for any positive denial of this principle. At the very close of the elaborate discussion of losses by condensation, it is stated that, "if there be any portion of the stroke during which the steam loses the form of vapor, a dynamic effect measured by that portion and the *wanting pressure*, is lost." It is beyond reason, then, to claim that the indicator will not measure any such "wanting pressure."

This theory of special loss by condensation, in expanding, must be tested by its evidences. Various experiments have been made at different times and by different authorities, with different results. Pambour, on one side, determines a slight loss, while Pole invariably discovers a gain. We have notes of careful experiments on an engine working generally under one-fifteenth cut-off, where the sum total of all losses is 23·4 per cent. In other cases we have found it 16 per cent. As a matter of testimony by experiment, then, the "data" of the Board must face numerous results by no means "fallacious," or "specious," or "purely theoretical."

To return to the argument of the indicator cards:—In experiment No. 6, there is a loss in final pressure of 8 per cent., and in back-pressure, as referred to *mean pressure*, there is a loss of 14 per cent.,

and of 12 per cent. in *initial pressure.* In experiment No. 2, there is an excess in final pressure of 37 per cent. beyond that due to the initial steam and expansion, while the back-pressure is 20·6 per cent. of the mean pressure, and 8·2 per cent. of the initial. In experiment No. 7, the excess of final pressure is 95 per cent., the back-pressure being 42 per cent. of the mean, and 10·9 per cent. of the initial. Certainly there is no argument in such a state of facts as to losses *in the cylinder* by expansion, but there is a most fatal argument against the parade of accuracy, and perfect machinery, and valves which could not possibly be supposed to *leak.*

The experiments, as to back-pressure, confirm a point of simple demonstration, viz: that the reduction of steam volume per stroke involves a reduction of back-pressure, as referred to initial pressure, and that this item, in comparing similar volumes doing the same work, is not increased by expansion. All the subtle deductions of the report on this point are incorrect, being disproved by its own results. As to economy of work, it appears that there is an absolute excess of pressure at the highest rate of expansion, and nearly double the final pressure due to the Mariotte law, which is a waste of power and steam to an enormous extent, and is chargeable to leaky valves, being an item of credit to the expansion account. When we remember that in boiler priming the results in waste are formidable against full steam travel; that this matter of condensation as applied to expansion *per se* and compared with other palpable losses, can have but little effect; that the whole course of these experiments tends to prevent the true illustration of economy in expansion, and does not assert the opposite in result; we may well be content to rest the examination of results at this point. If the Erie Board, in expanding $\frac{4}{45}$ths, burned over 6 lbs. of coal per horse-power per hour, we may readily accept the testimony of those engines which, at the same expansion, burn 2 lbs. per horse-power.

A certain mechanical principle underlies and controls the whole question of expansion, although its connexion is not commonly recognised. A principle which belongs to the primitive formations of all engineering theory and is indissolubly united to the very elements of motion. Our allusion to it involves a slight historical discussion.

In the abstract of this report given in the April number of this journal, Watt is credited with the first application of expansion as suggested to him by the announcement of Mariotte's law. The writer is in error in two respects; first, by the fact that Hornblower preceded Watt six years in the application of expansion as a source of economy, and second, that Watt's original application of the cut-off was made in view of the great principle to which we allude, viz: the effect of the *mass of an engine in motion.* Nor is the speculation as to Watt's unpublished experiments on expansion leading him to adopt a steam travel of three-quarters probable, as he made the mistake of the Erie Board and vitiated the results within his reach by using too low pressure. He proposed in 1782 to cut off at one-quarter. Trevithick in 1806 apprehended the question of economy much more

fully, using steam at 40 lbs., and proposing to build an engine to cut off at less than one-sixth. And since that time, the whole Cornish school, instead of confining itself to this standard, has carried the grade of expansion in some cases to one-twentieth, not for purposes of experiment, but for regular duty. It is a very great mistake to suppose or to assert that, "until quite recently, it was the exception, and not the rule, to find new engines cutting off at less than one-half."

But without pausing here to sustain a very simple matter of record, we refer again to the fact, that when the genius of Watt superseded the *atmospheric* engine and used steam as a driving power, it also comprehended an inevitable law of motion, which demanded the application of the cut-off as a mechanical necessity, in advance of any idea of economy. We take an impregnable position, then, based on absolute principles, when we assert that the cut-off is an appurtenance which bears to every engine in full motion a relationship entirely independent of any question of economy, although this is a natural sequence, and that the idea of assuming full steam travel as a basis of comparative mechanical action is a misapprehension of engine duty.

The argument on this point is sufficiently clear in reference to all bodies in motion which have weight. To overcome the inertia of an engine, a certain surplus pressure must be applied to the piston, which corresponds with initial pressure, and is exceeded at no after point of the stroke. The mass being thus put in motion by charging it with surplus power, it is a mechanical absurdity to continue the initial pressure any farther than will suffice to complete the stroke by virtue of the surplus power imparted at the commencement. In the general application of this law, there is no distinction between single-acting and fly-wheel engines; mass in motion characterizes both.

It is an absolute necessity, then, in every engine, that the power necessary to complete its stroke properly, must be imparted to it in excess at an early period of such stroke; and inasmuch as the whole experience of the steam engine in practice abundantly confirms the theoretical conclusion that this surplus power may be exerted at a very early point of motion, this disposes of the expansion question, not only as to mechanical effect, but as to economy. For all the fine drawn arguments on condensation and re-condensation are of very little consequence to the mass which is by this time distributing its excess of power.

Viewed in this light, the doctrine of expansion divests itself of all incumbrances. We come back again to the principle of maximum useful effect. There is a given velocity to be imparted to a given load at the start. If a steam travel of four feet under ten pounds pressure will do it, who is to assert that a travel of one foot under forty pounds pressure will not do it equally well, better in fact, and much more cheaply? No experimental philosophy can prevail against a plain mechanical law like this, and certainly no such experiments as those we have here discussed. On the contrary, the most extensive, severe,

laborious research, by the first men of the age, has brought out this law "seven times refined" for the benefit of the world. So long as we know that the maximum velocity of motion can be imparted to an engine before it reaches the half-stroke, we decide the fallacy of any argument which prescribes any later point of cut-off; and we also decide that the only limit to economy of steam by expansion, is to be determined by the practicable conditions of such initial motion, and the practicable perfection of construction.

Paper from Wood.

Many years ago, a M. Watt succeeded experimentally in manufacturing paper of fine quality from woody fibre. But the large quantity of concentrated alkalies which he was forced to use in a highly heated state, prevented the practical introduction of his process. It appears that a French lady, whose name is not given in the *Cosmos* to which we are indebted for the following account, has succeeded in avoiding the difficulty by the use of a peculiar cutter, by which the wood is reduced to a species of *lint* before it is subjected to the reagents. This cutter consists of a series of parallel wheels, set close together on an axis, and armed with fine points, which penetrate the surface to a small depth (not more than one-hundredth of an inch), and are followed by a sort of plane which ploughs off the surface thus minutely divided. The material is then made into a pulp by the action of acids and alkalies, and bleached by chlorine. The paper thus made is said to be equal or even superior to linen paper, and to be fitted for use for fine impressions of engravings in place of China or India paper, while its cost is less than one-hundredth of that material.—*Cosmos.*

On the Nature of the Deep-Sea Bed, and the Presence of Animal Life at Vast Depths in the Ocean. By Dr. G. C. Wallich.

From the Lond. Engineer, No. 279.

(Continued from page 241.)

The *Foraminifera* are the organisms to which reference has been made as performing so very important a part in the formation of certain strata on the earth's crust. They occur abundantly in all existing seas. They are to be met with in a fossil state, not only in chalk, but in almost all marine sedimentary strata; as, for instance, in the hard limestones and marbles. The recent Foraminifera may therefore be looked upon as the oldest living representatives of any known class of organisms.

In the mud, or "ooze" as it has been termed, which is brought up from great depths in many parts of the open sea, immense assemblages of Foraminifera are to be met with, chiefly belonging to one species, however. In the absence of examinations conducted immediately on their being brought up to the surface by the sounding ma-

chine, it is not surprising that the question as to their occurrence in a living, or only in a dead state, should have remained undecided. Most of the authorities who have written on the subject being of opinion that they do not live at great depths, but that their shells and remains have drifted to the positions in which they were found from shallower waters, or have subsided from the upper strata of the ocean. Professor Huxley was one of the very few who leant to the more correct opinion; he having declared that, although far from regarding it as proved that the Globigerina (the species referred to) live at these depths, the balance of probabilities seemed to him to incline in that direction. Other writers have offered surmises on the subject; but these, in the absence of any thing like substantial proofs, were, of course, only estimated at what they were worth.

The difficulty is how to determine the point conclusively. For it seems legitimate to infer that, if these organisms are specially adapted to exist under conditions differing so widely from those present at or near the surface, the very circumstance of removing them from one set of conditions to the other, would inevitably destroy their vitality, and, perhaps, their normal structure, before it could become practicable to subject them to microscopic analysis. Nor is the difficulty an imaginary one. For, taking into consideration the entirely altered circumstances in which these creatures must find themselves placed when brought to the surface, locomotion, or even the protrusion of their filamentary appendages, could hardly be expected. The mere existence of the fleshy parts within their shells, and that too in an apparently recent condition, affords no proof, inasmuch as the great quantity of saline matter present in sea water, and especially at great depths, would, of itself alone, account for their perfect state of preservation.

During the recent survey of the North Atlantic, I found that, in certain localities where the Globigerina deposit was of the purest kind and in the greatest plenty, the specimens from the immediate surface stratum of the sea bed alone retained their normal appearance, both as regards the perfect state of the sarcodic contents of the shells, and the presence of the pseudopodia. The latter organs were never seen by me in an extended condition; but in the specimens alluded to, and in those only, occurred as minute bosses, resembling in shape the rounded rivet-heads on boilers, closely appressed to the external surface of the shell; whereas, in specimens from the sub-stratum, the color was much duskier, and these bosses were absent. And, further, in these pure deposits the shells were to be found in every gradation, from the single chamber, of microscopic minuteness, hyaline transparency, and extreme thinness, to the dense Zeolite-like structure of the many-chambered mature shells, which are large enough to be readily distinguished by the naked eye. These facts, when taken in conjunction with the entire absence of the varied remains of other organized structures found in localities where the Globigerinæ are only scantily represented, afford, as I conceive, all but the direct proof, which can only be arrived at on witnessing locomotion, or the

protrusion and retraction of the pseudopodia of the organisms in question.

Most fortunately, as it happened, this collateral evidence was rendered doubly conclusive by other proofs of a most unexpected and interesting kind. Before entering on these, I may state that the substratum, spoken of as differing in aspect from the immediate surface-layer, is, nevertheless, identical in composition; the difference in color arising simply from decay. It contains no living Foraminifera; for the minute particles of matter becoming gradually condensed and aggregated together by molecular affinity, and the enormous superincumbent pressure exerting itself only in one direction, that is, vertically, its permeability by fluids is thus completely destroyed, and it is compacted into a dense mass of far too unyielding a nature to admit of its being traversed by living creatures of any kind. As the Foraminifera die off, their shells and decaying contents, together with the minute particles of amorphous matter associated with them, go to build up the calcareous strata of the earth's crust. I would mention that, in order to determine whether the *Globigerinæ* live as free floating forms in the mid-strata of water, I attached a small open-mouthed bag, at about 200 fathoms from the extreme end of the sounding line, in a locality where the species was most abundant in the deposit, and brought it up through nearly 5000 ft. of water, without securing a single shell.

But by far the most important and interesting discovery remains to be noticed, viz: the detection of a high order of radiate animal in a living state, at a depth of a mile and a half below the surface of the sea.

When we take into consideration the low position of the rhizopod in the scale of being, and the obvious probability, pointed out by Professor Huxley, that a class of creatures proved to extend so far back in time—that is, in a fossil state—must be able to maintain existence under extraordinary and variable conditions as regards light, temperature, and pressure, the sentiment engendered is rather one of wonder that their vitality at great depths should have been so long and so stoutly maintained, than that it should now be so fully proved. But few persons were bold enough to suspect that creatures of a far higher type, viz: Radiata, could exist under similar conditions; and I freely admit that nothing short of the most incontrovertible proof ought to be accepted in support of such a view. Fortunately, I am in a position to afford that proof.

In sounding midway, in the direct line between Cape Farewell, the southern point of Greenland, and the north-west coast of Ireland, in lat. 59 deg. 27 min. N., and long. 26 deg. 41 min. W., the depth being 1260 fathoms (or 2520 yards), whilst the sounding apparatus itself brought up a considerable quantity of minute granular particles, looking like a fine oolite, but which was, in reality, a nearly perfectly pure Globigerina deposit, thirteen star-fishes, from 2 ins. to 5 ins. in diameter from tip to tip of rays, belonging to a genus plentifully represented on our own coasts, came up adhering to the extreme 50

fathoms of sounding line. These *Ophiocomæ* were not only alive on being brought up out of the water, but some of them continued for fully a quarter of an hour to move about their long spinous arms. To render intelligible the significancy of the entire circumstances, I must mention that, in order to insure accuracy, it is always necessary, when sounding in deep water, to ascertain the depth by one sort of apparatus, and to bring up the sample of bottom by another. In the present case, the ascertained depth was 1260 fathoms, and 50 fathoms was accordingly "paid out" in the second operation of bringing up bottom, in order to make sure that the more complicated and unmanageable apparatus required for this purpose fairly rested on the bottom.

Now, supposing it possible that these star-fishes were drifting about in some intermediate stratum of water, between the bottom and surface, it is evident that they would have attached themselves indiscriminately to any portion of the entire 1260 fathoms of line; unless, indeed, they chanced to have been directing their course in a closely compacted column, which was traversed by the last extra 50 fathoms of line at the precise moment of their crossing it. Whether it be possible that they were drifting in such a column, or floating on a bed of seaweed or other substance, is immaterial, inasmuch as they could only have attached themselves as they did to the portion of line referred to under this one condition. But the very act of attachment would, I maintain, be impossible in the case of creatures whose movements are so sluggish, when the object which they had to grasp was moving upwards at the rate of two miles per hour (as it does when hauled up by the steam engine), and without a moment's intermission. But even assuming it to be possible that they had drifted to the position in which they were captured, from distant and less profound depths, the fact of their vitality and vigorously healthy condition would be scarcely less extraordinary; for the distance from the nearest point of land, which is a rock off Iceland, is 250 miles; whilst the next nearest land, Greenland, is distant no less than 500 miles. But it must be obvious to every one who is at all conversant with the structure of the *Ophiocomæ* and Echinoderms generally, that they are essentially creeping and crawling creatures, and of far too great specific gravity to float at all under any circumstances.

Taking into consideration, then, the circumstances under which these *Ophiocomæ* were taken, the extreme improbability of their having drifted to the locality in which they were found from distant and shallower waters, and, lastly, the peculiarities of structure which render them wholly unfit to float or swim for even a brief period, we should have been fully warranted, I think, in believing that they existed in a living state at the bottom. In order to obtain some clue to the solu tion of the question, I very carefully dissected and analyzed the contents of the digestive cavity of a specimen, immediately on its being brought up; and was most amply repaid by the detection of numerous *Globigerinæ* in every stage of comminution, and with the contained sarcodic matter in greater or less quantity. Whilst, therefore, the detection of these organisms in the digestive cavities of the *Ophio-*

comæ, afforded a most conclusive proof that the Foraminifera were living on the sea bed at the profound depth from which they were obtained, the fact of the star-fishes being captured with the fresh remains of the Foraminifera in their digestive cavities, proves that their normal habitation is at the same great depth, inasmuch as it has been sufficiently established that the *Globigerinæ* are present only at the bottom. I may mention that, within the past few days, in examining a sample of the *Globigerina* deposit, brought up by a previous sounding on the same spot, I detected some Echinoderm spines, which at once struck me as being identical with those on the *Ophiocomæ;* and that, on comparison, my surmise proved to be quite correct: a further and very striking proof of the vitality of the *Ophiocomæ* at the bottom being thus afforded.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By WM. BRYSON, Civ. Eng.

D = diameter or side of the square of solid pillar in inches.
D = external diameter of hollow pillar in inches.
d = internal diameter of hollow pillar in inches.
L = length or height of the pillar in feet.
W = breaking weight of long pillars in tons.
Y = breaking weight of shorter pillars in tons.

Mr. Hodgkinson gives the following formulæ for the breaking weight of Dantzic Oak and Red Deal pillars, when the length of the pillars exceeds 30 diameters, both ends being flat and firmly fixed:—

Solid square pillar of Dantzic Oak (dry), $W = 10{\cdot}95 \frac{D^4}{L^2}$.

Solid square pillar of Red Deal (dry), $W = 7{\cdot}81 \frac{D^4}{L^2}$.

For shorter pillars, . . $Y = \frac{W c}{W + \frac{3}{4} c}$.

W = the weight calculated from either of the preceding formulæ.
c = the crushing force of the material.
Y = the breaking weight in tons.

The following formulæ are applicable for the breaking weight of solid cylindrical pillars of Dantzic Oak and Red Deal, both ends being flat and firmly fixed, and the length of the pillars exceeding 30 diameters and upwards:—

Dantzic Oak, $W = 6{\cdot}71 \frac{D^4}{L^2}$. Red Deal, $W = 4{\cdot}79 \frac{D^4}{L^2}$.

" $W = 4{\cdot}81 \frac{D^{3.55}}{L^{1.7}}$. " $W = 3{\cdot}47 \frac{D^{3.55}}{L^{1.7}}$.

Solid Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Side of the Pillar in inches.	Calculated breaking weight in tons from formula, $W = 10{\cdot}95\,\frac{D^4}{L^2}$.	Calculated breaking weight in tons from formulæ, $W = 10{\cdot}95\,\frac{D^4}{L^2}$, $Y = \frac{W\,c}{W + \frac{3}{4}\,c}$.
5	30	2		5·56
6	36	"		4·40
7	42	"	3·57	
8	48	"	2·73	
9	54	"	2·16	
10	60	"	1·75	
11	66	"	1·44	
12	72	"	1·21	
5	20	3		18·74
6	24	"		15·96
7	28	"		13·58
8	32	"		11·58
9	36	"		9·93
10	40	"		8·55
11	44	"	7·33	
12	48	"	6·15	
5	15	4		40·27
6	18	"		36·03
7	21	"		32·02
8	24	"		28·37
9	27	"		25·09
10	30	"		22·28
11	33	"		19 80
12	36	"		17·64
13	39	"		15·78
14	42	"		14·17
15	45	"	12·45	
16	48	"	10·95	
5	12	5		69·76
6	14·4	"		64·35
7	16·8	"		58 94
8	19·2	"		53·74
9	21·6	"		48·85
10	24	"		44·33
11	26·4	"		40 23
12	28·8	"		36·56
13	31·2	"		33·20
14	33·6	"		30·23
15	36	"		27·58
16	38·4	"		25·22
17	40·8	"		23·11
18	43·2	"	21·12	
19	45·6	"	18·95	
20	48	"	17·10	

Solid Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Side of the Pillar in inches.	Calculated breaking weight in tons from formula, $W = 7{\cdot}81 \frac{D^4}{L^2}$.	Calculated breaking weight in tons from formulæ, $W = 7{\cdot}81 \frac{D^4}{L^2}$, $Y = \frac{W c}{W + \frac{3}{4} c}$.
5	30	2		4·24
6	36	"		3·32
7	42	"	2·55	
8	48	"	1·93	
9	54	"	1·54	
10	60	"	1·24	
11	66	"	1·03	
12	72	"	0·86	
5	20	3		14·83
6	24	"		12·42
7	28	"		10·43
8	32	"		8·79
9	36	"		7·47
10	40	"	6·32	
11	44	"	5·22	
12	48	"	4·39	
5	15	4		32·64
6	18	"		28·76
7	21	"		25·22
8	24	"		22 09
9	27	"		19·36
10	30	"		17·01
11	33	"		15 00
12	36	"		13·28
13	39	"		11·81
14	42	"	10·20	
15	45	"	8·88	
16	48	"	7·81	
5	12	5		57·31
6	14·4	"		52·25
7	16·8	"		47·31
8	19·2	"		42·66
9	21·6	"		38·38
10	24	"		34·51
11	26·4	"		31·06
12	28·8	"		27·98
13	31 2	"		25·27
14	33 6	"		22·87
15	36	"		20·75
16	38·4	"		18·88
17	40·8	"	16·89	
18	43·2	"	15·06	
19	45·6	"	13·52	
20	48	"	12·20	

Solid Cylindrical Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from formula, $W = 6{\cdot}71 \frac{D^4}{L^2}$.	Calculated breaking weight in tons from formulæ, $W = 6{\cdot}71 \frac{D^4}{L^2}$, $Y = \frac{W c}{W + \frac{3}{4} c}$.
5	30	2		3 74
6	36	"		2·91
7	42	"	2·19	
8	48	"	1·67	
9	54	"	1·32	
10	60	"	1·07	
11	66	"	0·88	
12	72	"	0·74	
5	20	3		13·24
6	24	"		11·02
7	28	"		9·20
8	32	"		7·73
9	36	"		6·54
10	40	"	5·43	
11	44	"	4·49	
12	48	"	3 77	
5	15	4		29·42
6	18	"		25·78
7	21	"		22·49
8	24	"		19·60
9	27	"		17·11
10	30	"		14·98
11	33	"		13·17
12	36	"		11·63
13	39	"	10·16	
14	42	"	8 76	
15	45	"	7·63	
16	48	"	6·71	
5	12	5		51·99
6	14·4	"		47 16
7	16·8	"		42·50
8	19 2	"		38·15
9	21·6	"		34·21
10	24	"		30·63
11	26 4	"		27·46
12	28·8	"		24·68
13	31·2	"		22 22
14	33·6	"		20·07
15	36	"		18·17
16	38·4	"	16·38	
17	40·8	"	14 51	
18	43 2	"	12·94	
19	45·6	"	11·61	
20	48	"	10·48	

Solid Cylindrical Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from formula, $W = 4{\cdot}79\frac{D^4}{L^2}$.	Calculated breaking weight in tons from formulæ, $W = 4{\cdot}79\frac{D^4}{L^2}$, $Y = \frac{W c}{W + \frac{3}{4} c}$.
5	30	2		2·83
6	36	"	2·12	
7	42	"	1·56	
8	48	"	1·19	
9	54	"	0·94	
10	60	"	0·76	
11	66	"	0·63	
12	72	"	0·53	
5	20	3		10·36
6	24	"		8·49
7	28	"		6·99
8	32	"		5·81
9	36	"	4·79	
10	40	"	3·87	
11	44	"	3·20	
12	48	"	2·69	
5	15	4		23·60
6	18	"		20·30
7	21	"		17·53
8	24	"		15·10
9	27	"		13·04
10	30	"		11·33
11	33	"		9·89
12	36	"	8·51	
13	39	"	7·25	
14	42	"	6·25	
15	45	"	5·44	
16	48	"	4·79	
5	12	5		42·39
6	14·4	"		37·95
7	16·8	"		33·78
8	19·2	"		29·97
9	21·6	"		26·57
10	24	"		23·59
11	26·4	"		20·99
12	28·8	"		18·72
13	31·2	"		16·75
14	33·6	"		15·05
15	36	"	13·30	
16	38·4	"	11·69	
17	40·8	"	10·35	
18	43·2	"	9·23	
19	45·6	"	8·29	
20	48	"	7·48	

In the following table, Mr. Hodgkinson gives the relative strength of pillars of different British irons as obtained from 22 solid cylindrical pillars of cast iron, 10 feet long and $2\frac{1}{2}$ inches diameter, cast out of 11 kinds of iron (9 simple irons, and 2 mixtures). The pillars were all from the same model, and were cast vertically in dry sand, and turned flat at the ends, two being cast from the same kind of iron in each case. The simple unmixed irons tried were as below, and all of No. 1 iron.

Simple Irons.		Mean breaking weight in tons.
Old Park iron,	Stourbridge, .	29·50
Derwent "	Durham, .	28·03
Portland "	Tovine, Scotland, .	27·30
Calder "	Lanarkshire, .	27·09
Level "	Staffordshire, .	24·67
Coltness "	Edinburgh, .	23·52
Carron "	Stirlingshire, .	23·52
Blaenavon "	South Wales,	22·05
Old Hill "	Staffordshire, .	20·05

The pillars formed of mixed irons were found to be weaker than the three strongest of the unmixed series.

Respecting irregularity in the strength of cast iron, of which the solid pillars experimented upon were composed, Mr. Hodgkinson says, "They were always found to be softer in the centre than in the other parts. To ascertain the difference of strength in the sections of the pillars used, small cylinders, $\frac{3}{4}$ inch diameter, and $1\frac{1}{2}$ inches high, were cut from the centre, and from the part between the centre and the circumference, and there was always found to be a difference in the crushing strength of the metal from the two parts, amounting perhaps to about one-sixth. The thin rings of hollow cylinders resisted in a much higher degree than the iron from solid cylinders. As an example, the central part of a solid cylinder of Low Moor iron, No. 2, was crushed with 29·65 tons per square inch, and the part nearer to the circumference required 34·59 tons per square inch. Cylinders out of a thin shell $\frac{1}{2}$ inch thick of the same iron required 39·06 tons per square inch, and other cylinders from still thinner shells of the same metal, required 50 tons per square inch, or upwards, to crush them."

(To be Continued.)

On Electro-Chemical Coloring and the Deposition of Peroxide of Iron on Plates of Steel and Iron. By M. Becquerel.

From the London Chemical News, No. 83.

Priestly was the first to obtain colored rings by means of electricity,* by receiving strong charges from a battery, with surface of about two square metres, on metal plates, by means of metallic points directed perpendicularly to their surface.

* *Philosophical Transactions*, vol. lviii.

Nobili, in 1827,* afterwards produced colored rings on platinum, gold, silver, and brass plates, by putting them in communication with one of the two poles of a voltaic pile, plunging them into metallic and non-metallic solutions, and then by directing perpendicularly to their surface a platinum point connected with the other pole. With positive silver, for instance, and solution of sea-salt, he obtained a series of concentric circles surrounded with varied irises, the tints being slightly dimmed by contact with the air. On heating the plates all the rings took a red tint.

I began to study the electro-chemical coloration of metals in 1843,† my chief object being, not to produce colored rings, but to deposit on plates of gold, platinum, copper and silver, thin and uniform layers of peroxide of lead, presenting successively, according to the duration of the operation, which was generally very short, the rich colors of the spectrum. The operation consists in plunging into an alkaline solution of protoxide of lead the piece to be colored, put in connexion with the positive pole of a voltaic pile charged with nitric acid and composed of many layers of plates, and closing the circle with a platinum wire in communication with the negative pole, and of which but the point, which alone touches the alkaline solution, is continually in motion. In contact with the object to be colored, the protoxide of lead, which forms the positive electrode, super-oxidizes, becomes insoluble in the alkali, and deposits itself on the surface in slight adherent layers, producing the color of the thin plates. Air and light gradually fade these colors—a disadvantage I have already mentioned, and which may in great measure be avoided by covering the colored surface with alcohol varnish, which acts but very slightly on the peroxide. With a little practice all the tints desired may be given to a large object with hollows and projections, and each part painted with the appropriate color. These colors are now made fast by the processes to be described further on.

If the solution of protoxide of lead in potash is replaced by a solution of protoxide of iron in ammonia, and the gold, copper, or platinum plate by one of polished iron, there is deposited on the latter a layer of peroxide of iron with red or brown tints, which deepen more and more according to the thickness of this stratum, which never exceeds a certain limit on account of the imperfect conductibility of the peroxide.

In a paper on the precipitation of metals from their solutions by other more oxidizable metals,‡ I stated that on plunging a copper plate into a solution of double chloride of potassium and platinum, heated to 60°, the platinum is deposited and adheres to the copper, producing a platinization, which is quickly acted on by the air, taking first a slightly brownish tint, which becomes darker and darker.

This alteration is partly due to the presence of protochloride of copper, which is deposited simultaneously with the platinum towards the end of the operation. The protochloride may be removed by washing

* *Annales de Physique et de Chimie*, vol. xxxiv., second series.

† *Comptes-Rendus*, vol. xviii.

‡ Ibid.

the platinized copper with water and acetic acid, or by rubbing its surface with cotton and rouge. The alteration is then avoided, or at least does not appear until long afterwards, probably on account of the air traversing the interstices of the platinum, which with copper forms a voltaic pair. The brownish color of the platinum surface is like that which protochloride of copper ordinarily takes under exposure to air and light.

If we make use of platinized copper directly it is obtained from a solution of double chloride as a positive electrode to decompose water with a pile composed of several elements, it produces, under the influence of the oxygen disengaged from the positive pole, peculiar coloring effects, seeing that the tints pass immediately to blue and deep crimson, and the protochloride of copper is not modified by light. While in contact with platinum the latter metal doubtless contributes to the coloration. No similar result is obtained by operating with platinized plates previously treated with acidulated water or rouge. Furthermore, air has no effect on the colors produced—not an unimportant fact, as it will make it possible to obtain fast colors also with peroxide of lead.

Owing to the strata of oxide, the result is the same if heat is gradually applied to non-preserved platinized pieces, but the colors are less brilliant.

If a copper plate with a layer of peroxide of lead giving one of the beautiful colors of the spectrum is employed as a positive electrode to decompose the water, in a few moments it will be found that the coloration is preserved—a result similar to that obtained with platinized copper. By continuing the electro-chemical action for a quarter or half-an-hour, according to the force of the pile, the blue-violet tints fade, turning to green and yellow, as peroxide of lead. The basis of the coloration undergoes no change at the positive pole. It is thought that the acid secondary products formed at the positive pole react on the peroxide and decompose it.

The colored plates thus preserved seem to be in the same condition as iron when it has been plunged in nitric acid, or when it has been used as a positive electrode to decompose this same acid. It is then in an abnormal state, being unattackable by nitric acid.

When a very slight layer of platinum is electro-chemically deposited on a gold or platinum plate by means of a solution of double chloride of potassium and platinum containing no copper, this layer undergoes no change either by the action of the air, or when the plate is employed as a positive electrode to decompose water; but it is otherwise when the solution contains copper. The coloring effects before described are then produced, when the proportion of copper is small and the coloration of the platinum is not destroyed by weak nitric acid—an important advantage practically. In this memoir we have indicated a great improvement in the process of coloration, for by its means more uniform and adherent layers of metals are deposited.

Magnificent coloring effects are produced by a solution of double chloride of potassium and platinum in hyposulphite of soda.

Lastly, deposits of peroxide of iron on iron and steel, which are already almost unalterable by air, will become entirely so when the pieces have been employed as positive electrodes to decompose water.

Comptes-Rendus.

Application of Cyanide of Potassium in Soldering Metals.

From the London Artizan, July, 1861.

In the operation of soldering metals, says Dr. Augustus Vogel, it is very essential to keep the metallic surfaces to be united clean and bright, so that the solder may adhere firmly when in a melted condition. For the purpose of protecting the metallic surfaces from the oxidizing action of the atmosphere, certain fusible substances are usually rubbed on with the solder, and immediately form a thin layer over the surface of the metal. These substances produce, however, not only a protective, but also a reducing action. In practice it is sought to insure these two essential conditions in the choice of the substances generally employed, viz: For soft soldering, resin turpentine, olive oil, powdered sal-ammoniac, mixed either with oil, or with tallow and resin, or a very concentrated solution of chloride of zinc. For hard soldering, borax, or a melted mixture prepared from borax, potash, and common salt, and, in the special case of iron, pounded green glass is generally used. It is well known that the substances above mentioned fulfil to a greater or less extent these two conditions of soldering, viz: deoxidation and protection of the metal from the atmosphere. A material possessing these two qualifications, in the highest degree, would of course best effect this purpose. As the result of a great number of experiments, I have come to the conclusion that the ordinary commercial quality of cyanide of potassium possesses decided advantages in this respect over all other substances. It melts very readily, covering the surface of the metal with a very efficient protective layer, and at the same time is known to exert a strong reducing action, a property which has gained for it many important applications both in technical and analytical chemistry. Cyanide of potassium will be found particularly useful when the surfaces to be soldered cannot be thoroughly brightened. It is difficult, and sometimes impossible, to solder metals when their surfaces are at all corroded, or when they are incapable of bearing the high temperature necessary in this operation, with the ordinary agents, on account of their inferior reducing power; but cyanide of potassium, from its extraordinary energetic action, is able to deoxidize all rusty particles standing in the way of the perfect union of the solder with the metal. The mode of applying the cyanide of potassium in soldering is the same as with borax. Some powdered cyanide of potassium is kept ready at hand in a well-closed glass bottle, and sprinkled over the metallic surface after it has been slightly moistened. In some cases of soldering at very high temperatures, which by practice are soon ascertained, it will be found expedient to use a compound of borax and cyanide of potassium, for the purpose, on the one hand, of increasing by

this addition the small reducing power of the borax, and on the other hand, of diminishing the volatilizing tendency of the cyanide of potassium. Another reason for preferring the employment of this agent is, that during the operation no corrosive vapors capable of acting on the soldering tools are generated, as is the case with chloride of zinc.

Mulley's Auxiliary Steering Apparatus. By W. R. Mulley, Esq., Surveyor to Lloyd's, Plymouth.

From the Lond. Mechanics' Mag., January, 1861.

Gentlemen—Will you kindly allow me space for a few remarks on the present insufficient means of steering steamships of large tonnage, and a brief description of my auxiliary rudder as a remedy.

Rudders and the apparatus for moving them have, since the introduction of steam, occupied considerable attention, and many improvements been made in both. But owing to the immense size of the ships now built, and their extreme length in proportion to beam, together with the effect produced upon the rudder by the screw, the difficulty is greatly augmented; indeed, to such an extent does this exist in some ships, that on a recent trial of one of the finest frigates in our navy, she was, when at full speed, quite beyond all control of her helm.

To remedy such deficiencies, and also to provide a reliable resource in the event of damage to the main rudder, I have devised an auxiliary. It is about half the superficial area of the main rudder, oblong-shaped, and formed of separate bars of copper or iron—according as the ship may be of wood or iron—in such manner as will allow it to twist (its action resembling that of the fin of a fish) in and out of the quarter where it is hung, at an optional depth below the water-line, and when not in use recessed so as to take the shape of the bottom, leaving no projection whatever, and consequently free from the various risks of injury to which the main rudder is liable—that of being shot away in particular, a casualty, now that rifled cannon will be used and directed with so much precision, infinitely more likely to occur than heretofore. The auxiliary rudder would in such cases be quite efficient for the safe navigation of the ship; whereas without some such substitute immediately available, she would be in a far more helpless condition than the loss of her screw would render her, concerning which much has been said and many suggestions made to guard against, as of course while her masts were standing she would still be under control. It would also be highly serviceable for ships, such as iron-cased batteries and others navigating shallow waters and intricate rivers. The auxiliary rudders are worked each by a common steering wheel, placed on either side and near that of the main rudder, and are operated upon simultaneously with it under the same orders, having, in a case of sudden change of helm, the advantage of being brought to act at once, while the main one has first to pass its neutral point. The other part of the apparatus consists merely of a vertical and horizontal shaft, with a pair of wheels and pinion to move a segment-shaft passing

through the ship's side and connected to the after end of the rudder, so that it requires but a small quantity of room from the hold.

Although the auxiliary rudder is undoubtedly calculated to be of greater service to ships of war than merchantmen, yet, as they can be carried without inconvenience, the comparatively trifling cost ought to be no bar to their adoption in long-voyage passenger ships, contributing as it would so much to the security of life. It may be urged that such accidents are of rare occurrence, to which I would reply by asking what amount of money would be thought too much when they do happen for such a help at hand?

Lloyd's Register Office, Plymouth, December, 1860.

On the Preparation of Artificial Coloring Matters with the Products Extracted from Coal Tar. By M. E. Kopp.

From the Lond. Chemical News, Nos. 44 and 46.

(Continued from page 256.)

Preparation of Nitro-benzole.—The preparation of nitro-benzole is accomplished, on the large scale, by allowing a fine stream of benzole and another of the strongest nitric acid to run together in a worm or long glass tube kept well cooled. The two liquids react on each other on coming in contact, heat is disengaged, and nitro-benzole is formed. Commercial nitric acid, mixed with half its volume of sulphuric acid, may be substituted for the concentrated nitric acid. The nitro-benzole collected at the end of the worm, is first washed with water, then with a solution of carbonate of soda, and afterwards once again with water.

Nitro-benzole is a yellowish liquid which at 15° C. has the sp. gr. 1·209.* It boils at 213°, and cooled to 3° it crystallizes in needles. Having an odor closely resembling that of the essential oil of bitter almonds, it has been largely used in perfumery for scenting fancy soaps, for which purpose it has one advantage over the oil of bitter almonds—it is less affected by the action of alkalies. It is almost insoluble in water, but is very soluble in alcohol, ether, and the essential oils. Concentrated nitric and sulphuric acid dissolve it, but it is precipitated on the addition of water. It is decomposed by continued boiling with concentrated sulphuric acid; and under the same circumstances with concentrated nitric acid it forms bi-nitro-benzole. Neither the alkalies in strong aqueous solution nor quicklime act on nitro-benzole; but an alcoholic solution of the alkalies acts energetically, and forms azoxybenzole ($C_{24}H_{10}N_2O_2$). By the action of nitric acid on this last substance a number of other interesting bodies are produced, which, however, it is not necessary now to describe.

Transformation of Nitro-benzole into Aniline.—This is effected by a variety of processes, which we shall proceed to describe in detail.

1. *By means of Sulphide of Ammonium.*—An alcoholic solution of nitro-benzole, after having been saturated with ammoniacal gas, is treated with a current of sulphuretted hydrogen. The liquor now becomes of a deep dirty green color, and deposits a little sulphur. It is

* Stated erroneously by M. Parisel (*Chem. News*, vol. ii. p. 96) to be 1·080.

now left for twenty-four hours, during which time crystals of sulphur are deposited, the odor of sulphuretted hydrogen disappears, and is replaced by a strongly ammoniacal smell. If distilled now to recover the alcohol, a good deal of sulphur is deposited, and it is impossible to continue the distillation long, because of the violent bumping which ensues. It is therefore allowed to cool, and the sulphur is removed. On distilling the liquor again, more sulphur is deposited, which must also be removed. The process must be continued, re-saturating the liquor with sulphuretted hydrogen if need be, until a heavy oily matter (aniline) deposits, which must be separated from the liquor and re-distilled by itself. The aniline is thus obtained nearly pure.

Instead of using an alcoholic solution of nitro-benzole, and treating it successively with ammonia and sulphuretted hydrogen, the alcoholic solution of sulphide of ammonium may be prepared beforehand, and the nitro-benzole poured into it. A part is dissolved immediately, and the remainder by dryness in the course of the operation. It is sometimes advantageous, instead of waiting until the aniline separates, to add hydrochloric acid to the liquor in the retort until it is slightly acid, and then to distil almost to dryness, by which means chloride of aniline is obtained. This is decomposed by an excess of caustic soda, and the aniline set at liberty is distilled off.

To avoid any danger from the bumping, a tinned copper still must be used, which should be heated by steam under a light pressure. At first the temperature should not exceed 90° C., but after some time it may be raised to 100° or 110°.

The ammoniacal alcohol condensed in the worm may be re-saturated with sulphuretted hydrogen, and used over again with a new quantity of the nitro-benzole.

2. *Reduction of the Nitro-benzole by nascent Hydrogen.*—In preparing aniline by this process, the nitro-benzole and zinc are placed in a vessel, and dilute sulphuric or hydrochloric acid is added, so as to produce the disengagement of a small quantity of hydrogen. By degrees the nitro-benzole disappears and aniline is formed, which remains in solution in the hydrochloric or sulphuric acid. To isolate it an excess of caustic soda is added and the mixture is distilled, on which the aniline passes over with the vapor of water.

Bechamp first recommended the employment of acetic acid and iron filings. He places in a retort one part of nitro-benzole, one and a half parts of iron filings, and one part of concentrated acetic acid. The reaction takes place without the application of external heat, the mixture becoming hot by itself, and the vapor being condensed in a receiver, which must be kept well cooled. The condensed products consist of aniline, acetate of aniline, and some unchanged nitro-benzole. These are allowed to cool, and are then returned to the retort and again distilled to dryness. The distillate is now treated with potassa fusa, and the aniline separates as an oily layer, which must be removed and distilled once more.

The residue of the mixture of iron filings, acetic acid, and nitro-benzole, which remains in the retort after the distillation, still contains

a considerable amount of aniline. To obtain this, the retort must be washed out with water acidulated with sulphuric or hydrochloric acid, and the solution filtered, and then evaporated to dryness. The dry residue is then mixed with quicklime, and placed in a retort of iron or refractory ware, and distilled; and the aniline thus obtained must be rectified.

3. *Reduction of Nitro-benzole by Ferrous Acetate.*—Ferrous acetate reacts on nitro-benzole and converts it into aniline, while the sulphate, chloride and oxalate of iron have no action on it. The reaction is represented by the formula—

$$C_{12}H_5NO_4 + 12\,FeO + 2\,HO + \bar{A} = 6\,Fe_2O_3 + C_{12}H_7N + \bar{A}.$$

One part of nitro-benzole is placed in a retort with an aqueous solution of acetate of iron. The retort is then heated over a water-bath for several hours, and then the contents are filtered—being diluted with water if they have become pasty. The residue left on the filter, which is principally hydrated peroxide of iron, is washed with boiling water. The filtrate and washings are then distilled, the condensed products being water, acetic acid, and acetate of aniline. These may be again distilled with strong sulphuric acid (using four-tenths the weight of the nitro-benzole employed), to recover the acetic acid and form sulphate of aniline, and the latter may be decomposed by caustic potash and the aniline distilled off. This process has not been found advantageous, and has consequently been given up.

4. *Reduction of Nitro-benzole by means of Arsenite of Potash or Soda.*—This process was invented by Wöhler. He digested nitro-benzole with a solution of arsenious acid in a strong ley of caustic soda, or placed the arsenical solution in a tubulated retort, heated it to the boiling point, and then allowed the nitro-benzole to fall in drop by drop. Under these circumstances nitro-benzole is transformed into aniline, which distils over, and it is only necessary to saturate with an alcoholic solution of oxalic acid to obtain perfectly pure oxalate of aniline.

The last method of forming aniline we shall quote is that of Schlagdenhausen, who has shown that it is produced when nitro-benzole and sulphide of carbon are heated together in a sealed tube to 160°.

*Properties of Aniline.**—Aniline when pure is a colorless liquid, very astringent, having an aromatic odor, and an acrid burning taste. It is slightly soluble in water, and very soluble in alcohol and ether. Its sp. gr. = 1·028; at —20° it does not freeze. It boils at 182°, and distils unchanged. When warmed it dissolves sulphur and phosphorus. It is a powerful base, combining with acids to form salts, which in general are soluble. It decomposes ferrous and ferric salts, and the salts of zinc and alumina precipitating from them the metallic oxides. It also precipitates the chlorides of mercury, platinum, gold, and palladium; but it does not precipitate the nitrates of mercury and silver.

Aniline easily oxidizes, turning yellow in water, and in time becoming resinified.

* Gerhardt, *Chimie Organ.* iii. p. 84.

When aniline dissolved in hydrochloric acid is acted on by chlorine, the solution takes a violet color, and on continuing the current of chlorine the liquid becomes turbid, and deposits a brown-colored resinoid mass. On submitting the whole to distillation, vapors of trichloraniline and trichlorophenic acid pass over.

A solution of the alkaline hypochlorites colors aniline a violet blue, which passes rapidly to a pale red, especially in contact with acids.

A mixture of hydrochloric acid and chlorate of potash act on aniline, the final result of the action being choranile $C_{12}Cl_4O_4$, but in the course of the reaction several colored intermediary bodies are formed.*

If a solution of chlorate of potash in hydrochloric acid be added to a solution of a salt of aniline mixed with an equal volume of alcohol, and care is taken to avoid an excess of the hydrochloric solution, a flocculent precipitate is deposited after a time of a beautiful indigo blue; this precipitate filtered and washed with alcohol contracts strongly, and the blue color passes to a deep green. The filtered liquid has a brownish-red color; on boiling it, adding fresh quantities of hydrochloric acid and chlorate of potash, a yellow liquor is obtained, which deposits crystallized scales of chloranile.

An aqueous solution of chromic acid gives with solutions of aniline a green, blue, or black precipitate, according to the concentration of the liquors.

When a small quantity of an aniline salt is mixed in a porcelain dish with a few drops of strong sulphuric acid, and a drop of a solution of bichromate of potash is allowed to fall on the mixture, a beautiful blue color appears after some minutes, which, however, soon disappears.

Dilute nitric acid combines with aniline without altering it immediately; but after some time nitrate of aniline crystallizes in the form of concentric needles, the mother-liquor turns red-colored, and the sides of the capsule become covered with a beautiful blue efflorescence. When a few drops of strong fuming nitric acid are poured upon aniline, it is immediataly colored a deep blue; on applying heat the blue tint quickly passes to yellow, and a lively reaction is manifested, which results in the formation of picric or trinitrophenisic acid.

Potassium dissolves in aniline, disengaging hydrogen, whilst the whole becomes a violet-colored pap.

The other reactions of aniline, which are characterized by the formation of anileine, fuchsine, azaleine, will be related in a future number, when describing the processes for the preparation of these substances. But before commencing these we may just glance at some of the properties and derivatives of binitro-benzole.

Binitro-benzole, as before stated, is formed when nitro-benzole is added drop by drop to a mixture of equal parts of fuming nitric acid and sulphuric acid as long as the liquids will mix. If such a mixture be boiled for a few minutes, it becomes on cooling a thick magna of binitro-benzole, which is easily purified by repeated washings with

* See *Chem. News*, vol. ii. p. 195.

water. A single crystallization from alcohol will furnish the body in long brilliant prisms, which melt at a temperature above 100°, and crystallize again on cooling in a radiated mass.

Binitro-benzole is very soluble in warm alcohol. When a plate of zinc well cleaned is placed in a cold alcoholic solution of binitro-benzole and a hydrochloric acid is added by degrees, we observe that the disengagement of hydrogen, which at first takes place, soon ceases, and at the same time the liquid gradually takes a crimson-red tint.* The reaction being completed, the excess of zinc is removed, and the liquor is saturated by an alkali, which precipitates the oxide of zinc colored a deep purple. The precipitate is collected on a filter and washed with alcohol. By distilling the highly colored alcoholic washings, washing the residue with cold water, then redissolving it in alcohol and evaporating it afresh to dryness, the new matter is obtained perfectly pure. The authors have given it the name of nitrosophenyline. It has the formula $C_{12}H_6N_2O_2$. When obtained as above, it is a black shining substance; when heated, it fuses and decomposes directly; it is almost insoluble in water, but freely soluble in alcohol and acids. An alcoholic solution containing only 0·2 per cent. is so deeply colored that by reflected light the solution seems opaque and of an orange-red.

Concentrated hydrochloric acid and dilute sulphuric and nitric acids form magnificent crimson-red solutions with nitrosophenyline, which is precipitated from them again unchanged by alkalies.

Binitro-benzole treated with an alcoholic solution of sulphide of ammonium is at first converted into nitraniline,—

$$C_{12}H_6(NO)_4N = C_{12}H_6N_2O_4$$

that is to say aniline, in which one equivalent of hydrogen is replaced by one of nitrous vapor. Nitraniline crystallizes in yellow needles, which stain the epidermis like picric acid.

(To be Continued.)

On the Jet.

From the Lond. Mechanics' Magazine, July, 1861.

In a large steamer, lately built at Liverpool, a series of jets were introduced into the chimney in aid of the draft, on the supposed principle which produces such efficiency in the locomotive. In the centre of the chimney, a short distance above the boiler, a two and a half inch tube, forming a circle of two feet diameter, was introduced. In this were drilled sixty orifices, each of a quarter inch area. Through these the steam issued continuously, in a vertical direction, the jets being but one inch apart. That such an arrangement was made without a due consideration of the nature of the jet, or the principle on which its efficiency depends, will be manifest from the following:

Under the conviction that the several jets were so near each other that to a considerable extent they must have neutralized the action

* Church and Perkin, *Quart. Jour. Chem. Soc.* ix. p. 1.

and effect of each respectively, an apparatus of the same dimensions was made and inserted in a tube representing the chimney. The airmetre, hereafter described, was attached so that the entire quantity of air brought in had to pass through it. As no other access of the air was possible, the movements of the metre-vane gave a true measure of the quantity obtained in aid of the natural draft. The following experiments, which were then made, will sufficiently explain the importance of considering the relative position of the several jets, and the value of this metre test.

In the first experiment, the sixty quarter-inch orifices, one inch apart, were all open, the pressure of steam in the boiler being 7 lbs., and which pressure was continued throughout, as shown in the table annexed. The steam having been let in, and a due time allowed for the whole to be thoroughly heated, the number of revolutions of the metre were accurately noted. In this case the revolutions were 540 per minute, and this may be taken as evidence of 540 cubic feet of air brought in aid of the draft.

In the second experiment, each alternate orifice was plugged up, thus reducing the number of jets in action from sixty to thirty, and increasing their distances apart from one to two inches—necessarily with a saving of one-half the expenditure of steam. The result was, an increase in the number of revolutions of the metre (or cubic feet of air per minute) from 540 to 625, as noted in the following table, being a gain of seventeen per cent. in the effective chimney draft, with but one-half the expenditure of steam.

Experiments with Air Metre and Steam Jets.

Revolutions of Metre per minute.		Pressure in Boiler.	Number of Jets.	Size of Jets.	Gross area of Jets.
					Inches.
1-4th-inch Jets,	540	7 lbs.	60	1-4th-inch.	2·945
	625	"	30	"	1.472
	745	"	20	"	·981
	725	"	15	"	·736
	700	"	12	"	·589
1-8th-inch Jets,	740	"	60	1-8th-inch.	·736
	615	"	30	"	·368
1-10th-inch Jets,	700	"	60	1-10th-inch.	·600
	600	"	30	"	·300

In the third experiment, a further reduction in the number of orifices and jets was made, their distances being then three inches apart. The result was a further increase of revolutions and cubic feet of air passing, from 625 to 745, or a further gain of nineteen per cent., with a commensurate saving of steam.

Thus, the increased effect produced solely by placing the jets further apart, say from one to three inches, and thus allowing the several induced currents of air a more lengthened scope for action, was, an increase of draft from 540 to 745 cubic feet per minute, or a gain of

thirty-five per cent., with a saving of two-thirds the quantity of steam. It is needless to dwell on the value of this source of economy.

The next series of experiments with the air-metre consisted in the reduction of the areas or size of the several orifices and jets of steam from one-fourth of an inch to one-eighth, and then to one-tenth of an inch. In each case, as shown in the table, the results were remarkable. We there see that thirty jets of even one-tenth of an inch sectional area, if placed at three inches apart, were more effective than sixty jets of a quarter of an inch when placed within one inch of each other, as was the case in the apparatus as originally constructed.

As regards the economy of steam, the inspection of the last column in the table, giving the gross area for the exit of the steam in each experiment, is sufficiently expressive. This needs no comment. Here we have practical results arising from a just appreciation of the principle on which the efficiency of the jet depends, in opposition to the mere random application of a most useful power in aid of the natural draft in chimneys.

By the use of the meter we come so near to the absolute quantity of air introduced that it practically satisfies all that may be required. The metre consists of an ordinary circular vane, through which the air has to *pass* during the operation, producing motion like that of a windmill, increasing in rapidity in proportion to the strength of the current passing through it. This circular motion of the vane is transferred to a series of dials, similar to those of the ordinary domestic gas-metre. The number of revolutions of the vane are then truly recorded in units, tens, hundreds, &c., up to 100,000, thus enabling an experiment to be continued during above 100 minutes. The vane is eighteen inches in diameter, and having ascertained by a measured cylinder, after a true adjustment of the leaves, that the quantity passed during a given number of revolutions was equal to one cubic foot for each revolution, it was taken as a sufficiently reliable datum for calculating quantities. The number given by the index dials, then, will represent the number of cubic feet that have *entered* a furnace or been *drawn out*, as the case may be, or have escaped by the chimney, under the different circumstances of high or low temperature, with partial or complete combustion.

The vane is hung with such delicacy, and is so easily set in motion, that the loss by friction of the machine need scarcely be taken into account.

By the use of this apparatus, numerous practical errors have been corrected touching the quantities of air required, first, for the combustion of the *coke portion* of the coal resting on the bars in the furnace, and passing through the ash-pit; and, secondly, the quantity required for the combustion of the *gas portion* in the chamber, the appearance of smoke giving unquestionable proof that the requisite amount of air had not been introduced.

Of the value of the jet system, and the important service it may be enabled to perform, it is important to consider the insufficiency of the natural draft in reference to the quantity of air required in large

boiler furnaces, and in effecting perfect combustion. For this purpose it must be borne in mind, that the quantity of air absolutely required for the combustion of the gas portion alone of bituminous coal—as, for instance, the Newcastle—is at least one-half that required for the coke, or solid portion of the same. In a word, if the coke of a ton of coal requires 200,000 cubic feet of atmospheric air, the gas of the same ton weight will require 100,000 cubic feet—a fact but little thought of by boiler-makers; yet without this full equivalent of air much of the gas portion is not only wasted, but, by its conversion into smoke and soot, seriously impedes the action of the boiler, and in particular the tube portion of it. This latter, or 100,000 cubic feet, must be supplied to, and mixed with, the gas generated *above the fuel*, in the chamber of the furnace; while the 200,000 cubic feet have to be supplied by the *ash-pit*, and pass up through the solid fuel on the bars.

Now, where the heat-absorbing surface is well applied in the generation of steam (which is rarely the case) in marine boilers, the natural draft is invariably deficient. Here then we have, by the aid of an artificial draft, through the medium of the jet system, the direct means of effecting the perfect combustion of the whole of the combustible portion of the coal. That this is imperfectly understood, or but little thought of, by those who construct such boilers, we have an absolute proof in the generation and evolution of that mischievous nuisance, the dense volume of smoke, which characterizes all steam marine boilers using bituminous coal.

Finally, we may conclude that the efficiency of the jet system depends mainly, if not exclusively, on the amount of induced current, combined with a judicious arrangement of the several jets, keeping them in harmony with the area of exit of each, the pressure to which it is subject, and the space of freedom allowed for the several induced currents to exercise their maximum effect.

On the Composition of Cast Iron and Steel. By M. E. Fremy.

From the London Chemical News, No. 78.

(Continued from page 262)

These bodies were reduced to very fine filings, and this metallic powder, freed from all foreign matter, was submitted at a red heat to the action of dry hydrogen. In these three trials, the filings during the whole of the experiment disengaged considerable quantities of ammonia. This experiment leaves no doubt on the subject, and proves that nitrogen, contrary to the hitherto received opinions, is a constituent of steel. Steel is not, then, a simple carburet, but a nitro-carburet of iron.

If I be not deceived as to the bearing of my inquiries, it appears to me that they ought to have a certain influence on the metallurgic operations relating to the manufacture of steel. Thus, in the cementation of iron, all the conditions appear to be realized which give to the metal not only carbon but also nitrogen. It is probable that the

different qualities of steel depend on the duration of the cementation, and also on the relative proportions of the two elements which combine with iron. In the preparation of steel by puddling, it is equally important to determine what are the varieties of iron most likely to yield the proportion of nitrogen required for the constitution of steel; or those which, not containing sufficient, require to have it imparted while being converted into steel.

I have spoken of a steel which has for bases carbon and nitrogen; but this compound is not the only iron alloy the composition and properties of which are of interest to metallurgical industry. It is probable that bodies bearing some analogy to carbon or nitrogen would serve also in the production of steels. Is it not already known that granulated iron, which is harder than ordinary iron, and which in some respects is allied to steel, is principally obtained by the reduction of minerals containing phosphorus? If the combination of iron with carbon and nitrogen ought to be taken as the type of steel, it would be very curious to determine the modifications undergone by iron when carbon or nitrogen are replaced by other simple bodies. I shall devote another communication to this interesting subject, showing that there are many steels, and that they form a whole group of compounds, each of which ought to be successively examined.

It appears to me that the following conclusions may be drawn from the new facts which I have communicated to the Academy:—

1. In studying the successive or simultaneous action of nitrogen and carbon on iron, ammonia may be used advantageously to furnish nitrogen, and lighting-gas carbon; the chemical reactions thus produced by gases, yield pure compounds; they can be easily observed and regulated.

2. When iron has been submitted, not for too long a time, to the action of ammoniacal gas, it produces no crust of nitride of iron, it is simply nitrogenized, becomes then of a zinc white, partly preserving its malleability, and resembling a real alloy.

3. Iron heated in a current of lighting gas, immediately becomes carburetted and transformed into a very soft, grey, graphite-like, fusible cast iron, which is suitable for the finest castings. Steel is never formed in this reaction of lighting gas on cast iron.

4. Steel is formed by the reaction of carbon and nitrogen on iron.

5. Pure iron which, under the influence of lighting gas, is transformed into very fusible cast iron, is previously nitrogenized, loses its fusibility, and is converted into steel by the action of the gas. Fragments of the same metal have been nitrogenized for different lengths of time, and then submitted to the action of lighting-gas; those retaining a small proportion of nitrogen were very incompletely converted into steel; those, on the contrary, which were strongly nitrogenized, formed a beautiful steel. It is, then, in some measure, the quantity of nitrogen contained by iron during carburation which determines the degree of acieration.

6. It does not seem to me possible to admit that cementation may be produced exclusively by a carburetted volatile body, since lighting

gas acting at red heat on iron forms only cast iron, while by the previous presence of nitrogen in the metal, it is immediately converted into steel.

7. When iron is transformed into steel, the nitrogen is not eliminated by carbon, for I have ascertained that all the steels of commerce are nitrogenized, and disengage an abundance of ammonia when submitted to the action of dry hydrogen.

8. All these facts tend to the following conclusion, which is a condensation of my paper:—That steel is not, as it has hitherto been considered, a carburet of iron, but rather a nitro-carburetted iron. I have adopted the title of nitro-carburetted iron to explain the composition of steel, because it well expresses my opinion of the composition of this body, in which such small proportions of metalloid so completely modify the properties of iron.

The paper having been read,

M. Dumas rose and congratulated M. Fremy and the Academy on the important results which must flow from the labors of the author of the paper. The theory of the production of steel seemed henceforth determined, and it might reasonably be hoped that great practical results would ensue. Who, for instance, did not forsee—and it was for M. Fremy to follow out the demonstration—that great advantage would result from these new, methodical, regular, and certain processes, when there was occasion either to case-harden the surface or edge of certain iron implements or instruments? After having forged, filed, and finished them off in the state of iron, a current of ammoniacal and carburetted gases would convert them more or less completely into steel. The depth of the stratum of steel being regulated by the duration of this gaseous cementation with a certainty never obtainable by cementation with powders, or by the use of horn or animal matters in the empirical processes. The Academy could but congratulate M. Fremy on his present success, and on his disinterestedness in publishing his important labors.

M. Morin remarked that M. Fremy's researches explained numerous empirical receipts and processes for the cementation of steel. In most of these processes, mixtures were employed containing various proportions of carbon, and of more or less nitrogenized substances, such as ammoniacal salts, horn shavings, leather cuttings, soot, &c., &c., the result being a cementation more or less deep, according to the use to which the instruments are to be applied. He thought it necessary also to observe that the character of steels produced by different methods varied greatly, not only where these methods differed, but also with almost identical processes. Moreover, certain kinds of steel, and it seems particularly those obtained by puddling, after undergoing many energetic fagotings, appear to be susceptible of losing their characteristic properties of hardness and elasticity acquired by tempering, and to acquire a considerable resemblance to the most ductile irons. Lastly, the cast steels produced by the new processes of fabrication, when properly forged, possessed an elastic resistance

capable of undergoing a much greater strain than those manufactured by the ordinary methods.

Besides the foregoing speakers, several members of the Academy joined in the discussion when M. Fremy's paper had been read, and, among other remarks, it was stated that the composition of cast iron might be different to that of steel. M. Chevreul then made two observations, one respecting black cast iron, and the other on the composition of steels.

1. *On Black Cast Iron.*—At the end of the last century (1799), Proust observed that, when treated with weak sulphuric acid, black cast iron yielded an oily matter, a portion of which was carried off by the hydrogen gas and made the tubes of the apparatus greasy, while the other portion remained mixed with the black residue, from which alcohol could extract it. I never neglect an opportunity of quoting this observation of my illustrious fellow-citizen, as an example of the possibility of producing, by chemical forces, compounds analogous to those of organic nature. Experience has long since proved that aqueous vapor by reacting on charcoal, yields, besides carbonic acid, or oxide of carbon, nothing but hydrogen, and not carburetted hydrogen, as hitherto believed:* the combination of the cast steel with the nascent hydrogen seeming to me difficult to admit; this has led me to conjecture that in Proust's experiment the water might assist in the production of the oily matter simultaneously with the carbon and hydrogen. Now, M. Fremy's observations seem to throw a light on the subject, by indicating that it is not carbon, as was represented, which yields the oily matter.

2. *Composition of Steels.* — Independently altogether of science, two bodies possessing different properties have never been confounded; so that when an iron was observed which hardened on being suddenly cooled, it was distinguished from one preserving its original ductility after undergoing the same cooling influence. Thenceforward, the name of steel was bestowed upon the first substance to distinguish it from what is properly called iron; or, in other words, between steel, which tempering hardens, and iron, which tempering does not harden. Since the time of the revival of chemistry, the difference between steel and iron was attributed to the presence of about a thousandth part of carbon in the former. Later, the influence of various bodies on steel was recognised. Berthier mentions chromium; Faraday and Stodart aluminium, platinum, and its accompanying metals; but the fact which to me seems of the greatest importance, is the method by which MM. Faraday and Stodart obtained from cast iron some centièmes of iridium and osmium, which when analyzed yielded no trace of carbon. Setting aside the question whether steel is an indefinite compound of iron and one or several simple bodies distributed through the whole mass of the steel, or whether it is a definite compound of iron with one or several simple bodies distributed in indefinite proportions in the iron in excess of the elements of the definite compound, I conclude, from the whole of the facts I have stated, that in a chem-

* "Eighth Lesson on Chemistry Applied to Dyeing," pp. 23, 24.

ical treatise steel in general must be regarded not as a definite compound by the nature of its constituent parts, but as a particular state of iron produced by the union of this metal with bodies the nature of which is variable; and it is from this point of view that, after defining steel, independently of all scientific considerations, as an iron which is hardened by tempering, I discriminate in my fourteenth lesson on "Chemistry applied to Dyeing," published in 1829, p. 78:—

1. Steels formed by iron and carbon;
2. Steels formed by iron, carbon, and a third body;
3. Steels formed by iron and some other body, which is not carbon; or uncarbonized steels.

The results of M. Fremy's interesting experiments are, it seems to me, easily connected with what is already known of steel, if looked upon from the point of view I have explained, instead of regarding them in the general way. It is now important to find out—1, Whether it is true, as Guyton says, that diamond dust will turn iron into steel; 2, Whether acieration can be effected without the intervention of nitrogen.

M. Fremy said, in reply to the preceding observations, he was happy to observe the interest the Academy took in his inquiries on steel, and he thanked its members for the friendly way they had spoken of his labors. It was not his intention to treat, in the present communication, of the influence exercised by nitrogen and carbon on the properties of iron, but all questions relating to the fabrication of steel and cast iron had for a long time been carefully studied in his laboratory, and the results would by-and-by yield materials for papers bearing on the following points:—

1. The relative proportions of nitrogen and carbon required to be introduced into iron to form good steel;
2. Circumstances opposing acieration or altering the qualities of a steel when formed;
3. The mode in which carbon penetrates the metallic mass;
4. The reason why such small quantities of carbon and nitrogen can convert iron into steel;
5. The study of steels containing metals such as manganese, chromium, tungsten, aluminium, &c.;
6. Classification of different kinds of cast iron; examination of the effect which silicium, phosphorus, arsenic, and sulphur exert upon these compounds; study of the cast iron best suited to the fabrication of puddled steel.—*Comptes-Rendus.*

On a Standard of Length By Henry Hennessy.

From the London Athenæum, June, 1860.

Mr. Taylor's letter, in your last number, has called to mind certain points which I had omitted in my communication of May 5. The calculations referred to by Mr. Yates in his "Essay on a Standard of Length," were deduced by me from the results and formulæ of Bessel, in his "Memoir on the Elliptic Spheroid of Revolution which most

nearly corresponds with the Existing Measurements of arcs of the meridian," "Taylor's Scientific Memoirs," vol. ii., and "Astronomische Nachrichten," No. 333. As my results have not been published, I may be permitted to refer to such as bear upon the matter under discussion. I assumed the one-hundred-millionth part of the earth's axis as the proposed standard of length, instead of the forty-millionth of a meridian, which constitutes the French metre. I found the length of the proposed metre to be about 5·004774 English inches; in other words, I made the polar diameter of the earth to be about 500,477,400 instead of 500,491,440, referred to by Mr. Taylor and Sir John Herschel as the result obtained by the Astronomer Royal. My result makes the millionth part of the earth's axis still closer to five hundred inches than that to which attention has been called in your pages. At the time I communicated my calculations to Mr. Yates, I was not so much struck by the coincidence between the proposed metre and the British inch as to call particular attention to the matter. Although the circumstance appeared interesting and valuable, I still regarded it as only a coincidence; and I fully concur with the judicious remarks of Col. James, in the *Athenæum* for May 19, as to the desirableness of not attaching exaggerated importance to accidents of this kind.

A subject immeasurably more important is touched on by Mr. Taylor, when he speaks of the advantage of saving the country from the French metre. In so far as the metre is less perfect, as a scientific result, than the fraction I have deduced from the earth's axis, I concur with him; but in so far as it is merely French, I cannot assent to his conclusion. Many years after the publication of the *Principia*, it was a point of national honor among a certain set of French *savans* to prefer the vortices of Descartes to the so-called British system of gravitation. Have we all an equal right to smile at this kind of patriotism?

But if the metre happens to be French on account of its derivation from a measurement across France, it is not at all true that the system of measures associated with it is essentially French. I refer to this because any remarks touching the metre are frequently applied to the whole metrical system. The decimal arrangement of that system is as much common property to the mental habits of the members of the ten-fingered human race as the earth's axis is common to the various countries on which they exist. I hope, therefore, that questions of nationality will be as completely excluded from discussions of this kind as they have long happily been from other portions of the exact sciences.

Wynnefield, Rathgar, June 5.

Improved Steam Engine Indicator.

M. Bourdon has successfully applied the flat bent tube of his steam gauge to a steam engine indicator, the action of which is, we learn, all that can be desired. The card is carried on a flat plate which is made to rise and fall at each double stroke of the piston.

On the Unit of Length. By James Yates.

From the Lond. Athenæum, June, 1860.

Although the adoption of a certain portion of the earth's axis as the Unit of Length was suggested at the very first meeting of the International Decimal Association at Paris, in September, 1855, and was considered and discussed at a meeting of the British Branch of the Association at London, in 1857, yet the reproduction of this proposal in two specific forms, by so distinguished a philosopher as Sir John Herschel, seems to require some remarks in vindication of those who still adhere to the "boasted Metrical System of our French neighbors."

The two units, proposed by Sir John Herschel, are the 500 millionth part of the earth's axis, equal to 1·001 inches nearly, and the 10 millionth of the same, equal to 50·05 inches nearly. As the author does not appear to aim at any international system, I shall endeavor to meet him on his own ground, and to consider only the objections applicable to his units for English purposes. These are, their inconvenience and their inaccuracy.

First, their *inconvenience.*

One of them, *the inch*, is much too small: the other, which may be called *the ell*, is too large. A unit of length ought, if possible, to be such that it will represent that length, or something not very far from that length, which is more commonly used than any other for linear measurements. Supposing the system of measures to be decimal, the unit ought to be as nearly as possible at the middle point between the highest and lowest denominations, so that the numbers may increase as much by decimal multiplication in ascending as they diminish by decimal division in descending. Now, an inch might require to be divided in some rare cases into 100, or even 1000 parts, but, going in the other direction, it would require to be multiplied by 1000 times 10,000, and thousands of thousands, so as to require rows of figures which would be unmanageable. The lowest unit of length ever used for general purposes, has been the palm of 8 or 10 inches, used in Italy. Mr. Whitworth, of Manchester, has taken the British inch as a unit for a peculiar class of English manufactures requiring only very minute subdivisions, and many of his brother machinists have followed him. But for all the ordinary purposes of the shop and the market, as well as for the calculations of engineers, architects, surveyors, astronomers, and many other trades and professions, such a unit would be intolerable.

On the other hand, Sir John Herschel's ell would be too long. There cannot be a better test of the fitness of such a measure to be generally useful than the trial of it in measuring cloth. The length of this ell, of more than 50 inches, would require a constant effort in stretching out the arms, which would be fatiguing to men, and still more to women. The best unit for ordinary purposes, being adapted for common every-day operations, must be seen at a glance of the eye, easily handled, easily carried from place to place. I believe no better length

than the metre was ever contrived for these purposes. A unit of length so great as that proposed by Sir J. Herschel, has seldom, if ever, been used by any nation, and, I apprehend, the reason is, that it is not adapted to the frame of man. Sir Charles Pasley, though he is no admirer of the metre, admits its superiority in this respect. "It is," says he, in his Memoir read at Cheltenham, "a more convenient measure for cloth than the old French *aune*, which was rather too long for that purpose." Yet this "old French *aune*" was shorter by above 3 inches than Sir John Herschel's proposed measure. The importance of the same view of the question is recognised by the Commission appointed last year by the Imperial Academy of St. Petersburg, who observe, in reference to the idea of making the English foot the basis of a decimal system, "Le pied est trop petit pour mesurer des étoffes ; une mesure de dix pieds serait trop grande."

Secondly, The *inaccuracy* of the proposed new units. After all the objections urged against the metre on the ground of inaccuracy, it was little to be expected that accuracy should be disregarded by its opponents, or that they should propose any new unit which does not surpass the metre in this respect. Yet Sir J. Herschel's units are inaccurate in a double sense. He compares them, on the one hand, with the English linear measures, and, on the other, with the supposed length of the earth's axis: they do not exactly correspond with either; yet he treats the difference as a matter of no consequence. The difference of his new inch from the English inch is 1 in 1000; supposing this thousandth part to be added, its difference from the 500-millionth of the earth's axis would be 1 in 106,000.

Although we ought to aim at absolute identity in weights and measures, and to avoid a mere approximation as tending rather to augment confusion than to abate it, I am disposed to agree with Sir John Herschel, that so small a difference as 1 in 106,000, or even 1 in 1000, is of no practical importance, and would not be estimated in the ordinary operations of trade and commerce. I only say of his new standards and of the metre, "Trutinâ ponantur eâdem." I make this concession, even although the practical difference would be in reality two or three times as great as 1 in 1000, because the operations of trade consist in the vast majority of cases in weighing, and in solid or superficial, not linear measurements, and in all these cases we have to do, not with straight lines, but with the squares and cubes of those straight lines. It ought also to be remembered, that the supporters of the metre have never asserted its absolute accuracy as the 10-millionth part of the quadrantal arc; they have never discouraged or opposed any operations or inquiries which might lead to greater precision in determining the figure and dimensions of the earth; and they have provided by the alteration of the standard temperature of the original metre for any change in its length which may be found necessary.

With respect to the question of taking the earth's axis as a basis of calculation instead of a meridian, I am compelled to dissent from those who prefer the more novel course. If the axis is taken, it is calculated either from a medium or average of two or more meridians, or from

one meridian only. General Schubert thinks it best to assume one meridian only. If this be done, there is an end of the argument founded on universality and the absence of national predilections. Some of the English have opposed the metre, because it was computed from an elliptic meridian passing through France;* Schubert prefers the Russian meridian, and having computed from it alone, and then from the Indian meridian alone, the length of the axis, he combines the two computations, but gives to the Russian twice the weight of the Indian. Thus the axis is exposed to objections of the same kind as the meridian. Sir J. Herschel indeed asserts that the axis is "the more primary and fundamental unit." But, although this may be true in reference to the formation of a circle or ellipse in abstract mathematics, or according to some metaphysical conception, yet in the present instance the contrary is the truth. The periphery, or a definite portion of it, must be ascertained first, and from this calculation the axis must be deduced.

All the most recent discussions, not only those of Col. Everest and Sir Henry James, but even those of Schubert, Airy, and Sir John Herschel himself, seem to me to prove that the exact form and dimensions of the earth, and more especially its oblateness, and the length of its axis, are not yet determined with perfect accuracy. The emphatic words which form the very first sentence of the "Base du Système Métrique," are still true, viz: that "the two questions of the earth's size and its figure, which have so long employed astronomers and geometers, appear to be of such a nature that they will never be entirely set at rest." The assumption that the earth is an exact ellipsoid of rotation, and that all its meridians are true ellipses, equal to one another, is contrary to all evidence, both geological and geodetic. As to the superiority of the Russian arc, I presume there will be no dispute. The French arc was taken when the Metrical System was invented, for good, solid reasons, which had not their foundation in any national or exclusive partiality. This arc lay partly to the north and partly to the south of the mean parallel of north latitude, 45°, so as to admit of a good comparison with the indications of the pendulum; it was longer than any which had then been ascertained, viz: $9\frac{1}{2}°$; its northern and southern extremities were in contact with the sea; and, being the most recent measurement, it might naturally be supposed to have had the advantage of all improvements which the course of time had introduced. All these arguments, except the first, are now applicable to the Russian arc, the length of which is 25° 20′, extending from the mouths of the Danube to the Arctic Sea. The friendly communications which have taken place between the British branch of the International Association and many of the most distinguished Academicians of Paris and Brussels on the one part, and the Academy of Sciences at St. Petersburg on the other, afford a decisive and pleasing indication of a willingness on all sides to accept the Russian arc; and the same generous disposition is conspicuous in the great

* Sir J. Herschel speaks of it as "passing through *Paris*," which is a mistake; it lies considerably to the east of Paris.

work which does so much honor to our country, the latest publication on the Ordnance Survey of Great Britain.

But does it follow, because the Russian Academicians have thus far succeeded in making the best measurement of a meridian, that the metre is to be relinquished? By no means. The labors of Struve and his coadjutors in Russia, no less than those of Bessel in Prussia, and of Lambton and Everest in India, tend on the whole to confirm the conclusions of Méchain and Delambre in France; because the lengths of their meridians all come within a wonderful degree of proximity, and, in fact, present no difference which is important in regard to common affairs, or in respect to the intercourse of nations for commercial and political purposes. The Commission, lately appointed by the Imperial Academy of St. Petersburg in consequence of the application made to them by the International Association, and consisting of MM. Kuppfer, Jacobi, and Ostrogradski, have reported in favor of the metre, and many of the best-informed and influential men in that country are ready to support their opinion. This may lead to a general agreement upon the standard temperature at which the metre shall be taken in future. It may be found expedient to declare, by the universal consent of those who wish for an international system, that instead of requiring the metre to have, when used as an exact standard, the temperature of melting ice, it shall be 1, 2, 3, or any other number of degrees higher. Thus strict science may be satisfied together with philanthropy. The change may be made, although not an individual, except here and there a solitary astronomer, knows that there is a change. The 10,000,000th part of the quadrantal arc, whether it be deduced from the French or from the Russian measurement, and represented, as it now is, by a bar of platinum, will scarcely differ by an amount equal to the thickness of a film of varnish upon the extremities of the instrument. The whole question, so far as regards practice, is a mere scientific refinement.

May, 1860.

A New Method of Decomposing Hypochlorite of Lime, in order to effect what is known as the "Discharge."

From the Lond. Practical Mechanic's Journal, September, 1860.

A few years since, M. Steinbach, director of the establishment of Messrs. Steinbach and Koechlin, instituted some experiments in the hope of obtaining some improved process for effecting the bleaching and the discharging of dyed fabrics. A solution of bleaching powder was printed upon pieces of cloth, which were subsequently dried by being passed over a heated cylinder, in order that the hypochlorite of lime should become converted into chlorate of lime and chlorate of calcium. The experiments were most successful, and constituted an important progression in the bleaching and discharging of fabrics. In applying this process to madder-dyed fabrics a great inconvenience arose, in that pieces dyed in reds or pinks were sensibly discolored. To overcome this great defect, hypochlorite of zinc, or rather those products which result from the decomposition of hypochlorite of lime by means of sulphate of zinc, are employed. The *modus operandi* is

the following:—A mixture composed of water, 100 parts, by weight; gum, 50 parts; sulphate of zinc, 40 parts; is printed on the dyed fabric, and when dried the piece is immersed for two minutes in a cold bath, consisting of a solution of hypochlorite of lime, marking two degrees Baumé.

This new process for effecting the "discharge" is much more rapid, more certain, and very much more economical than the old method; the difference being the value of sulphate of zinc compared with that of tartaric acid.

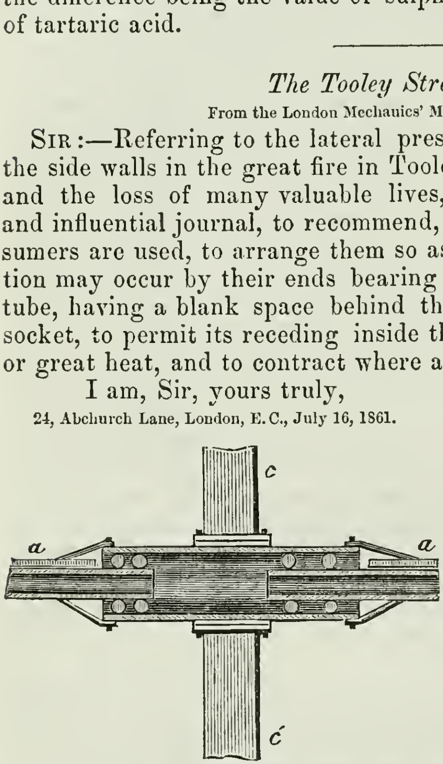
The Tooley Street Fire.

From the London Mechanics' Magazine, July, 1861.

Sir:—Referring to the lateral pressure of the cast iron beams on the side walls in the great fire in Tooley Street, causing their falling and the loss of many valuable lives, I wish, through your valuable and influential journal, to recommend, where iron beams and brestsumers are used, to arrange them so as their expansion and contraction may occur by their ends bearing on rollers in an open socket or tube, having a blank space behind the end of the brestsumer in the socket, to permit its receding inside the tube or socket in case of fire or great heat, and to contract where affected by severe cold.

I am, Sir, yours truly, George Walcott.

24, Abchurch Lane, London, E.C., July 16, 1861.



P. S. A socket or tube containing rollers might be let into the side walls instead of being fitted to the pillar supporting the floor. *a*, *a*, is the floor: *b*, is the cornice closing floor, and permitting the floor to roll into the socket or tube. *c*, a pillar supporting an upper floor; *c′*, a pillar supporting the floor beam. *d*, is a tube or socket open at both ends for receiving and allowing for expansion or contraction.

The Pyrometer. By M. A. Nobel.

From the Lond. Practical Mechanics' Journal, September, 1860.

Serious difficulties have hitherto presented themselves in the construction of a really exact pyrometer. M. Nobel, an engineer at St. Petersburg, has long been engaged in the study of the heat developed by furnaces of various kinds. As the result of his experiments, he has recently brought out a very simple apparatus, most easy of application and exact in its indications. This apparatus consists essentially of a cylindrical vessel or chamber, composed of platinum or other refractory substance, capable of withstanding a considerable degree of heat. This chamber is connected by a tube with a pressure indicator or manometer. Bourden's is found to answer well. The vessel is

placed in the furnace, and the tube is passed through a luted opening in the side thereof, and is connected at its outer end with the manometer. The inventor of this apparatus states, that bearing in mind that at a temperature of 1600°, the pressure of the air contained in the chamber upon the manometer would be about equal to six atmospheres, he suggests that by reason of the high temperature of the vessel, inconveniences may arise, and that it would be advisable to employ a rarified gas, which would give the following results at the temperatures given below:—

¼ atmospheres,	. . .	0° cent.
½ "	. . . .	266° "
1¾ "	. . .	1600° "

M. Nobel also remarks, that the gas contained in the external pipe not being at a temperature equal to that in the chamber, errors may arise; but, by proper calculation, these errors may be rectified, and considerably reduced by reducing the diameter of the pipe, to the smallest possible dimensions. The length of the pipe will depend upon the application of the apparatus. If the pipe is very short outside the apparatus of which the temperature is to be ascertained, it may be kept cool by a water-bath. By using a very sensitive Bourdon's manometer, and by adding thereto an apparatus for showing the number of revolutions of the needle or indicator, the increasing temperature for each degree will be readily arrived at, allowance being made, of course, for the atmospheric pressure on the apparatus itself. In practice, however, such allowance has not been found absolutely necessary.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, October 17, 1861.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from the Royal Society of London.

Donations to the Library were presented by the Royal Geographical Society, the Statistical Society, the Zoological Society, the Society of Arts, and the Commissioners of Patents, London; R. H. Lamborn, Esq., Altoona, Penna.; the Philadelphia Board of Trade, John C. Trautwine, Esq., and Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of September was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (9) were proposed.

A. L. Fleury, Esq., of Philadelphia, made the following communication relating to a new process of refining iron and steel by induced electricity.

At the present time, when iron in its various forms enters so largely into the economy of life, holding a high place in the interests of Pennsylvanians, it would be difficult to exaggerate the importance to them of any discoveries simplifying and cheapening the processes of its manufacture. It is with this feeling that I take the liberty of addressing this communication to the Institute, joined also to the hope that iron manufacturers will give the subject due consideration.

Since the year of 1806, when Sir Humphry Davy in his Bakerian lectures, delivered before the Royal Institute in London, at first demonstrated the decomposition and recomposition of water, and other substances which were believed to be elementary, by the simple agency of electricity, we have received ample and most conclusive proofs that in this modification of power, in electricity, we have the most effective decomposing agent, and are by it enabled to destroy the chemical affinity with which impurities cling to other substances. Sir Arthur Wall of Birmingham, England, was the first who used galvanic electricity for the purification of iron. Some twelve years ago, he fully demonstrated the value of electricity as a refining agent, and had it not been for the trouble, expense, and danger, connected with his process, it would doubtless have found a speedy introduction. Mr. Wall used a large number of Smee's batteries and polar platina plates, in order to precipitate the positive impurities on the negative pole while the metal was in its melted state, in a manner similar to the ordinary galvanizing process. I had been experimenting for some time on the influence of electricity on metals, with the view of simplifying the application of this important agent.

The use of the now celebrated Ruhmkorff's induction coil (an apparatus not yet discovered at the time when Mr. Wall secured his English patent) presented some new and different effects from those of the ordinary galvanic battery. While the galvanic current destroys the old and produces new chemical affinity, the interrupted secondary current simply destroys the same, without producing the before-named effect of the continuous current. Before describing my experiments with induced electricity, I have to digress to another subject, which, though it may seem somewhat abstract, is still closely connected with the same.

Wherever we notice a cellular or fibrous texture in organized matter, we invariably find the presence of nitrogen. In the plant as well as in the animal fibre, nitrogen appears as the most necessary constituent. Why should not nitrogen have something to do with the fibrous condition of metals? The celebrated chemist Fremy, in Paris, has lately proved beyond a doubt that nitrogen is a necessary constituent of steel; I may perhaps succeed in proving that nitrogen is also necessary for the formation of the tenacious fibre in iron and other metals. I simply mention here this abstract idea because it seems to be somewhat connected with the experiments which I come now to describe.

Through the kindness of Prof. Frazer, I had procured a suitable induction apparatus, made by Mr. Ritchie in Boston, and assisted by Mr. Adams, a practical English iron manufacturer, I began a series

of experiments in one of the neighboring iron works. One of the best experiments was on about 3000 lbs. of old cast iron, similar in quality to some which has been sold in New York for $12 per ton; of which 900 lbs. at a time were placed in a double puddling furnace, without cinders, and heated to the usual degree. The broken secondary electric current was passed through the heated metal from side to side by means of two platina points, for about ten minutes only, during the stage of fermentation—the so-called "coming to nature" of the iron. At the same time, I introduced some nitrogenized hydrogen in the form of a small quantity of carbonate of ammonia. The heat seemed to increase considerably, and the electricity passed in dense multiplied sparks from side to side. I found by several successive experiments that the impurities of the iron, freed from their former combination, boiled up, and, meeting the nitrogenized hydrogen, were carried off, either as volatile cyanides, or in various hydrogen combinations, leaving a fine fibrous iron in the furnace.

(For the introduction of volatile salts or liquids into the iron, I contrived a hollow working tool, for the use of which, as also for the electric process, I have obtained letters patent.)

The iron after having been balled, was passed through the well-known Bordan's squeezer, rolled, *without reheating*, into plates, and finally cut into nails. This would give to the manufacturer a saving of about $5 per ton.

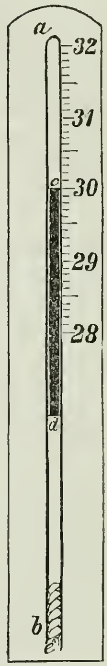
As I have made arrangement for the introduction of these and other improvements in the manufacture of iron and steel, in one of the largest works in this State, I shall be able to continue my experiments and communicate the results to the Institute.

Mr. W. Jones called the attention of the members to several specimens of rust taken from various parts of a government steamer's boilers, working in connexion with engines having surface condensers, and stated that Chief Engineer Wm. H. Shock, U. S. Navy, would make a few remarks in relation to the same.

Mr. Shock remarked that the specimens of rust referred to were from various parts of a marine boiler, working in connexion with engines having surface condensers, and showed the destructive character of some agent present in the boilers. He did not expect on the present occasion to do more than invite attention to the subject, in hope of exciting a spirit of inquiry, and eliciting investigation upon this very important question. His attention was first called to it some months ago, since which time he had diligently sought for the cause producing so serious effects. A Board, of which he was a member, had been appointed by the government to investigate the subject, but it was not yet ready to report.

He stated that a variety of opinions existed as to the cause of the serious deterioration of the boilers from which the specimens of rust before him had been taken, and a careful examination had led to the conclusion that it was owing to the presence of copper, and briefly explained his reasons, reserving a more lengthy and elaborate explanation of his theory for a paper he proposes to offer at some future day.

Mr. J. W. Nystrom exhibited to the meeting an improved Barometer, which consists of a glass tube, *a b*, of about $7\frac{1}{2}$ feet long, with a bore, slightly tapered, of about 0·07 of an inch mean diameter. The tube is closed at the smallest end, and filled with a column of mercury, *c d*, of about 32 inches in height, in the following manner. Place the glass tube in either an inclined or a vertical position, with the small or closed end downwards; run a fine iron wire down to the bottom of the tube, and pour in the mercury through a paper funnel; the air in the tube will escape along the wire, while the mercury will fall to the bottom. Draw the wire gently out, moving it forwards and backwards, so as to give time and opportunity for the air to escape with the wire; then place the glass tube in a vertical position with the small or closed end upwards, when the column of mercury will fall until its height balances the atmosphere. As the tube is larger at the lower end, the column of mercury becomes shorter the lower it falls; the rise or fall of the mercury is occasioned by different atmospheric pressures, and the range of the column in moving up and down is wholly dependent on the difference in diameter of the tube at the upper and lower ends. The scale is placed at the upper end of the tube, so that the top of the column indicates the height of the barometer. The scale is graduated either graphically by comparing it with a standard barometer, or by actual measurement of the column of mercury.



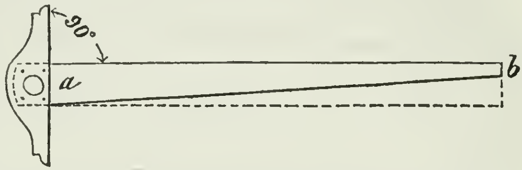
The lower end of the glass tube is filled to about one inch in height with a silk thread, *e*, to prevent dust from entering. Great difficulty has been experienced in procuring tubes of uniform taper. Experiments have been made with about 50 tubes, and only three of them were found to answer the purpose. In the best one of the three, the column of mercury had a uniform range of 48 inches for a difference of 2 inches in height; that is, as 24 to 1. This tube was accidentally broken; of the remaining two, which are now in use, and which were exhibited to the meeting, one has a range of 16 inches between 29 and 30 inches barometer height.

As the tube must necessarily be of very small diameter, the capillary attraction has a great influence on the real height of the column of mercury. In the tube of a mean diameter of 0·07 of an inch, when a height of 30 inches is indicated, on comparing with a standard barometer, the real height of the column is found to be only $28\frac{1}{2}$ inches; and in the tube with a mean diameter of 0·06 of an inch, an indicated height of $29\frac{5}{8}$ inches is equivalent to 30 inches of a standard barometer: so that for the same pressure of the atmosphere, the smaller tube carries a higher column. It might be supposed that some air remains in the tube above the mercury which reduces the column; but such is not the case, as may be readily shown by allowing the column to move up to the top of the tube, where such air would be detected.

I have had this instrument in my room since January last, about nine months, and have always found it correct and delicate. In stormy weather, I have seen the mercury rising and falling several inches in one minute, indicating the waves of the air ocean above us.

The same principle could also be applied to manometers for experimental purposes in delicate measures of densities of gases.

Mr. Nystrom also showed several specimens of improved T-squares. Simple as this instrument seems to be, it is difficult to procure one that will satisfactorily answer the purpose for which it is intended. The rule of



the square is generally made of hard wood, which is apt to warp, and it is heavy and clumsy to handle on the drawing board. The most suitable wood for a T-square is *spruce-fir*. This wood is not affected by a change of weather, and therefore will not warp; it is among the lightest of woods, its specific gravity when well dried ranging between 0·4 and 0·5, but it is too soft to be used against the drawing pen, in consequence of which, it is necessary to line the edges of the rule with a harder wood. It is of great importance with what kind of hard wood the spruce-fir rule is lined. Most of the hardest woods are not suitable for the purpose, as they warp and twist the rule, and in some cases will separate from it. Maple is found to be the best for the purpose. It is a fine grained, hard wood, and its specific gravity when well dried is only 0·6; its behavior in changes of weather coincides very much with that of spruce-fir, and it is therefore best adapted for this purpose.

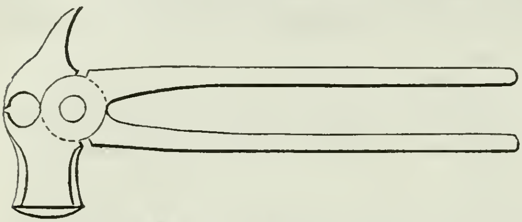
The squares shown to the members were made in Sweden; the one four feet long was made at the Technological Institute, Stockholm, in the year 1845, and it is as perfect now as when first made. The others were made about two years ago.

Another improvement in these T-squares is that the rule, *a b*, is tapered from the cross-piece to the other end; it is also much thicker at *a* than at *b*; this makes the square lighter and more agreeable to handle on the board. The one edge is at right angles, while the other can be set at any required angle by the movable part of the cross-piece. There is also another improvement in the manner of fastening the rule to the cross-piece. The space cut out in the cross-piece for receiving the rule is made fully $\frac{1}{32}$d of an inch smaller than the width of the rule, which latter is sprung in and fastened with four screws. Experience has shown that this mode of fastening the rule is far superior to that of gluing; besides, the rule can easily be taken out when it is required to adjust the cross-piece, which latter is generally made of rosewood.

I have had T-squares of this description for ships drawings, 10 feet long. The rule was 3 inches wide by $\frac{1}{8}$th thick at the cross-piece, and only 1 inch by $\frac{1}{16}$th at the other end. In order to handle such a long

square at the smallest end, a string was fastened at the screw in the cross-piece, extending to the other end, by means of which the square could be moved and set as delicately as if handled by the cross-piece. The edges are beveled down to a uniform thickness of about $\frac{1}{20}$th of an inch.

Mr. Nystrom also showed a combination of Hammer and Tongs,



and remarked that, an instrument of this kind is very useful about a house, store, or office. It originated from the inconvenience of traveling in Russia. In one journey from Sevastopol to Moscow, twenty-one days and nights were occupied in continuous traveling; during this time, the wagon or tarantass broke down or got out of order several times, and a hammer and tongs of this description was found to be very useful.

Mr. Howson exhibited a large and beautifully finished model of a Breech-loading Rifled Cannon, invented by Mr. T. M. Adams of this city. It has at the rear end of the bore an opening at right angles to the latter for the reception of a movable breech and a wedge, which are so connected together and to a lever, that by lowering the latter both wedge and breech are lowered simultaneously, leaving a clear opening for the insertion of the projectile from the rear of the cannon into the bore. On raising the lever, the breech is elevated to its proper position at the rear of the bore, and then tightly secured by the wedge.

Mr. Howson also exhibited specimens of the fibres of a plant of the genus Hibiscus which grows in abundance in the marshy lands of New Jersey and other northern States. The applicability of the fibres of this plant to the manufacture of paper, rope, matting, textile fabrics, &c., was discovered by Mr. Cantelo, the well-known inventor of the egg-hatching machine, which was operated so successfully in this country and Europe a few years ago.

Mr. H. also directed the attention of the members present to a Breech-loading Carbine, the invention of B. F. Joslyn, of the Joslyn Fire Arm Company, Stonington, Conn. The peculiarity of this fire arm consists of a tilting breech provided with two conical rings, which are caused to expand by the force imparted to a cone-headed pin, the moment the discharge takes place, thus securing perfect tightness at the breech. The weapon has been submitted to a series of trials at the Washington Navy Yard, where its performance received the commendation of the government officers appointed to inspect arms of this class.

Mr. H. also exhibited an Air-tight Preserving Vessel, invented and patented by J. B. Wilson, Esq., of Williamstown, N. J., and now sold in such numbers as to prove its efficiency.

Mr. Howson also exhibited a beautiful specimen of embossed brass, representing the bust of General McClellan, the dies for forming which were made in this city.

Mr. H. also exhibited a specimen of an improved Ventilated Hat, invented and patented by W. F. Warburton, Esq. The peculiarity of this hat is that it has in front a thin metallic band, which, while it adjusts itself readily to the wearer's head, allows the air to pass freely from below into the interior of the hat.

METEOROLOGY.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.

September.—The mean temperature of September (67·95°) was about the same as the average for eleven years, but was two degrees higher than for the same month last year.

The warmest day of the month was the 15th, of which the mean temperature was 75·5°. The 3d was but 0·2 of a degree colder. The highest degree indicated by the register thermometer was 86° on the 3d. On the 15th the highest point reached was 84°.

The coldest day was the 29th, with a mean temperature of 56·2°. The thermometer indicated the lowest temperature (46°) on the 29th. The range of temperature for the month was 40°.

The greatest change of temperature in the course of a day was 26° on the 23d; the least was 5½° on the 18th. The average oscillation for the month (17·22°) was one degree less than that for September, 1860; but was very near the average for the month for eleven years.

The greatest mean daily range of temperature was 16·3°, between the 21st and 22d; the least was 0·7°, and occurred twice, between the 9th and 10th, and between the 13th and 14th days of the month. The average daily range for the month was 4·41°, which was about one-third of a degree less than the average for eleven years, and about three-quarters of a degree less than for September, 1860.

The pressure of the atmosphere was greatest (30·343 ins.) on the morning of the 30th, and least (29·283 ins.) on the evening of the 27th. This minimum pressure is the lowest indicated by the barometer for this month in the last eleven years; the nearest approach to it was in September, 1859, when the minimum pressure was 29·338 inches. The average pressure for the month was three-hundredths of an inch below the general average, and six-hundredths of an inch less than the pressure for September, 1860.

The greatest mean daily range of pressure was 0·426 of an inch between the 28th and 29th; the least was 0·014 of an inch between the 1st and 2d days of the month; and the average for the whole month was 0·144 of an inch, which is a little greater than the average for the last eleven years, though almost identical with the range for September of last year.

The relative humidity, force of vapor, and dew-point were greatest on the 11th of the month; the relative humidity was least on the 1st, and the force of vapor and dew-point were least on the 29th. The relative humidity was greater than for any September for the last eleven years; and the force of vapor and the dew-point were higher than they have been since 1855, and considerably above the general average.

Rain fell only on six days of the month, reaching the aggregate depth of 4·976 inches, which is one inch more than usually falls in this month, and two inches more than the quantity which fell in September of last year.

There was not one day of the whole month entirely clear, but the sky was entirely covered with clouds at the hours of observation on five days of the month.

A thunder-storm occurred on the evening of the 3d of the month, and several buildings in the neighborhood of the city were set on fire by the lightning. Between 9 and 10 P. M., rain mingled with hail fell to the depth of an inch and three-quarters.

On the 17th and 27th other thunder-storms occurred, doing, however, but little damage in the neighborhood of Philadelphia.

A Comparison of some of the Meteorological Phenomena of SEPTEMBER, 1861, *with those of* SEPTEMBER, 1860, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Sep. 1861.	Sep. 1860.	Sep. 11 years.
Thermometer.—Highest, . .	86°	92°	95°
" Lowest, . .	46	42	39
" Daily oscillation,	17·22	18 20	17·03
" Mean daily range,	4·41	5·20	4·74
" Means at 7 A. M.,	62·37	60·28	62·56
" " 2 P. M.,	74·75	73·17	74·89
" " 9 P. M.,	66·72	64·02	66·64
" " for the month,	67·95	65·82	68·03
Barometer.—Highest, . .	30·343 in.	30·313 in	30·430 in.
" Lowest, . . .	29·283	29·597	29·283
" Mean daily range, .	·144	·143	·123
" Means at 7 A. M., .	29·953	30·003	29·982
" " 2 P. M., .	29·913	29·965	29 940
" " 9 P. M., .	29·924	29·998	29·958
" " for the month,	29·930	29·989	29·960
Force of Vapor.—Means at 7 A. M.,	·476 in.	·425 in.	·474 in.
" " " 2 P. M.,	·516	·437	·496
" " " 9 P. M.,	·532	·455	·516
Relative Humidity.—Means at 7 A. M.,	83 per ct.	77 per ct.	79 per ct.
" " " 2 P. M.,	60	50	56
" " " 9 P. M.,	79	72	75
Rain, amount in inches, . .	4·976 in.	2·907 in	3·859 in
No. of days on which rain fell,	6	7	7·9
Prevailing winds—Times in 1000-ths,	s75°28′w.·181	s74°36′w ·397	s87°21′ w ·216

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

DECEMBER, 1861.

CIVIL ENGINEERING.

Suspension Girder Bridges for Railway Traffic.

From the Lond. Civ. Eng. and Arch. Journal, Dec., 1860.

(Continued from page 298.)

Let us now pass on to the consideration of the condition which imposes the severest possible strain upon the snspended girder, namely, the distribution of a load over half the girder next one tower. Here we have no experiments recorded that supply any check to theoretical calculation. We may however the less regret the omission, when we find that the condition just supposed is the one in which the problem assumes its very simplest form.

We have already presented the result of the investigation of the effect of the concentrated weight w placed on the suspended girder, at a point whose distance d from the centre bears to the entire span s the ratio $\frac{d}{s}=r$. We found that the load thrown on the chains would be

$$\left(\frac{25}{16}-\frac{15}{2}r^2+5r^4\right)\times w;$$

and thence deduced the ordinate of the reflex wave. If for a concentrated load at one point we substitute a load equably distributed between two points (at the respective distances $d=rs$, and $d_2=r_2 s$,

from the centre), the rate of loading per foot forward being denoted by m, the load thrown on the chains will be readily found by integration to be equal to the following expression:—

$$\text{Load on chains} = \left(\frac{25}{16}(r_2 - r) - \frac{5}{2}(r_2{}^3 - r^3) + r_2{}^5 - r^5\right) \times ms.$$

And when one half-span is equably loaded, and the other half-span not loaded—that is to say, when $r_2 = \frac{1}{2}$ and $r = 0$, we find that

$$\text{Load on chains} = \left(\frac{25}{16} \times \frac{1}{2} - \frac{5}{2} \times \frac{1}{8} + \frac{1}{32}\right) \times ms = \frac{ms}{2},$$

which is exactly the amount of the load distributed over the half-span of the girder.

A load therefore, say of 100 tons, distributed over half the span of the suspended girder, induces an upward reaction in the chains equal to 100 tons distributed over the whole span. The unloaded half of the girder will therefore have to sustain an upward distributed pressure (from the chains) equal to 50 tons; the loaded half of the girder will have to sustain the difference between its load of 100 tons and the upward reaction of the chains, which will be 50 tons: this difference amounts to 50 tons, and is the net downward distributed pressure on the loaded portion of the girder.

It is therefore obvious that, apart from the stretching of the chains, the suspended girder will in this case assume a perfectly symmetrical S curve; the upward flexure of the unloaded half of the girder being exactly similar and equal to the downward flexure of the loaded half. The same result is arrived at by combining the simple wave of deflection with the reflex wave.

It thus appears that *for a bridge of a single span only*, the greatest strain which a given rolling load can throw on the suspended girder is $\frac{1}{8}$th of the greatest strain which it would throw on an ordinary girder not suspended.

Take, for instance, a bridge of 400 feet span, with a rolling load of 1 ton per foot forward. For a common girder bridge the greatest strain will be that which is sustained at the centre when the whole bridge is loaded; and will be represented by the product of 400 (the load in tons), and 50 (the eighth part of the span). This product is 20,000. For a suspended girder the greatest strain will be that which arises at the quarter-span, when the half-span is loaded. The rolling load is in this case 200 tons; but as the upward reaction of the chains distributed over the half-span is 100 tons, the load sustained by the girder is only 100 tons. The strain will therefore be represented by the product of 100 (the virtual load in tons), and 25 (the eighth part of the half-span). This product is 2500, which is $\frac{1}{8}$th of 20,000, the greatest strain on the simple girder bridge.

We have hitherto postponed the consideration of the stretching of the chains when the rolling load comes on the bridge, and the consequent depression of the reflex wave. Let us suppose a uniform elonga-

tion of the chain, at the rate $1 : 1 + e$; and s being the span, let v be the rise of the curve of the chains; then $\frac{25e}{32}\left(\frac{s^2}{4v} + \frac{4v}{3}\right)$ is the expression for the settlement at the half-span due to the assumed amount of stretching of chain; and this will be the consequent diminution of the sagitta of the reflex wave.

The rise or fall of the girder occasioned by the contraction or expansion of the chains on change of temperature is expressed in a form identical with the preceding; and the consequent strain on either flanch of the girder can be readily computed when the depth of the girder is known. And when the section of the girder is known, it will be easily ascertained what amount of additional load is thrown upon it, from the deflection attending the stretching or the expansion of the chains.

In brief, for a bridge of a single span, the section of the suspended girder should be calculated to give $\frac{1}{8}$th, not of the entire strength of a simple bridge girder for the same span, but of so much only of its strength as is assigned to the support of the maximum rolling load. This distinction is one of great moment where heavy spans are encountered, and indicates the extreme economy of the suspended girder in such cases. All the fixed dead weight, inclusive of the weight of the girders themselves, is carried by the chains; with the exception that, when these expand or are stretched, a small distributed load is thrown on the girders. A *small* distributed load, because a girder of the proportionate strength required, and of a depth from one-third to one-half of the rise of the chains, will readily rise and fall to the necessary extent, without sustaining much strain. The girders could, moreover, be strained up to a camber, in fixing, so as greatly to reduce the downward strain resulting from the elongation of the chains.

As an illustration of this, let us suppose that the chains of a bridge of 400 feet span have a rise of 50 feet, and carry a girder of such rigidity that a distributed load of 50 tons would cause it to deflect 10 inches, were the support of the chains withheld. If a rolling load of 400 tons, covering the whole bridge, causes the chains to stretch $\frac{1}{2000}$th part of their length, the resulting deflection will be 4 inches: but the girder in deflecting 4 inches has a distributed load of only $\frac{4}{10}$ths $\times$ 50, or 20 tons, thrown upon it, leaving 380 tons as the share of the rolling load sustained by the chains. And were the girder strained up in fixing to a 4-inch camber (representing an upward pressure of 20 tons), the effect of the stretching of the chains would be simply to release the girder from its forced camber, so as to leave it free from strain when the bridge is covered with its maximum rolling load.

Apart from the deflection or settlement alluded to, the maximum rolling road will cause an extreme deflection at the quarter-span, equal to $\frac{1}{32}$ of the deflection which would take place at the centre of the same girder, under the same rolling load, without the chains; or about $\frac{1}{4}$th of the extreme deflection of an ordinary girder bridge of the same span and same depth of girder.

The case of the suspended girder, for a single span, having been thus far investigated, we may proceed to examine how the conditions become modified when there are more spans than one. If we suppose that, of two adjacent spans, one is loaded and the other not, we find that the chains on the opposite sides of the intervening pier will in the first instance be in very unequal states of tension, and that the one chain must sink and the other rise, until the equilibrium of tension is restored. This is presuming that the chains are connected, as is usual, by means of a saddle placed on rollers, so as to admit of such adjustment, and relieve the pier of any horizontal strain.

The necessity of this or some equivalent precaution, becomes manifest when we consider the nature of the horizontal strain that would otherwise be thrown on the pier or tower intervening between an unloaded and a loaded span. Take for instance two adjacent spans, each of 400 feet, of which one has only its fixed dead load, while the other is covered by a rolling load of 400 tons. If the rise of the chains be 50 feet, the horizontal tension of the one pair of chains will exceed that of the adjacent pair by 400 tons; so that, if the summits of the chains were made fast to the top of the tower (instead of being allowed to slide upon it), the tower would have to sustain a horizontal pull of 400 tons, tending to draw it over into the loaded bay. Could an ordinary pier be trusted to sustain a strain of this nature and magnitude, the foregoing part of our inquiry would be as applicable to bridges consisting of two or more, as to those of a single span; but prudence is generally considered to demand the exemption of masonry piers from such a formidable horizontal strain. Where iron is substituted for masonry, and a very extended base given, the towers might possibly be made to sustain a strain of this nature. But in such a case the summits of the towers would cease to be absolutely dead points, since unequal compression in the iron would inevitably cause a slight horizontal deflection towards the more heavily loaded span. This deflection, or swaying, of the tower, if only a few inches, would cause such a deflection in the loaded girder as we wish to avoid. We may therefore pursue our investigation into the case of two adjacent spans unequally loaded, the chains being allowed free play on the top of the intervening pier.

The function of the suspended girders will now be to equalize the strain on the chains, so as to insure equilibrium, before the deflection of one span and the drawing up of the other (which without the girders might be objectionably great) exceed some small fixed limit. If therefore, one span being unloaded, the adjacent span is covered with a rolling load of 100 tons, the action of the girders must be such as to throw a distributed load of 50 tons on each set of chains. The girders of the loaded span will therefore have to sustain a sensible load of 50 tons, the remaining 50 tons of rolling load being borne by the chains. At the same time, in the unloaded span, the reaction of the chains will distribute an upward pressure of 50 tons over the girders. These results will of course be modified by the stretching of the chains, which will diminish the rise in the one span, and increase the deflection in

the other. It is perhaps hardly necessary to remark, that as the waves in the adjacent spans are of opposite kinds, they will in no way be affected by continuity in the girders.

For a suspension bridge of more spans than one, designed for railway traffic, it therefore appears essential to provide girders capable of sustaining a distributed load equal to half the maximum rolling load. These girders should not be of a depth exceeding from one-third to one-half the rise of the chains. For large spans—and it is for large spans only that a suspension bridge would be constructed to carry railway traffic—these girders, having to support neither their own weight, nor any other portion of the dead load, but simply half the maximum rolling load, will be light in comparison with the girders for an ordinary bridge of equal span. They will be sufficiently flexible to follow the rise and fall of the chains; never ceasing to be truly *suspended* girders, at the same time that they possess rigidity enough to distribute any partial load equably over the chains, and to keep the wave caused by the rolling load within moderate and safe limits.

After what has been said, it is obvious that the economy of the suspended girder is greater for a single span than for a bridge of more spans than one, since the girder in the latter must be four times as strong as that in the former. The deflection in the bridge of one span only will (as we have seen) be one-fourth of the deflection of an ordinary girder bridge of the same span and same depth of girder; while in the multiple span bridge the deflection becomes equal to that of the ordinary girder bridge. The deflection in each case has, however, to be increased by the amount of settlement due to the stretching of the chains when the maximum rolling load traverses the bridge.

On examining the expression for this settlement, which has been already given as $\frac{25e}{32}\left(\frac{s^2}{4v}+\frac{4v}{3}\right)$, we find that it diminishes as the rise of the chains increases; reaching a minimum when the rise of the chains equals the altitude of an equilateral triangle having for its base half the span of the bridge. By giving a considerable rise to the chains, we therefore effect a saving of strength, and thus of material, not simply in the chains themselves, but also in the suspended girder, by reducing the strain on the latter resulting from settlement.

It may be as well before dismissing the subject, to add a word or two on the resistance offered by the chains *per se* to an irregular displacement, and the amount of error involved at the outset of this inquiry in neglecting this element of stability; and considering the *form* of the reflex wave as entirely governed by the law of the girder, while its *magnitude* depends on the law of continuity of the chains. If we take the same example as before, viz: a bridge 400 feet span, 50 feet rise of chain, and a dead load of 300 tons, inclusive of weight of chains and girder; and suppose a weight of 1 ton placed at the quarter-span; the chains over the same point would be drawn down about 1 inch, if there were no girder. But if we take the girder (of the same strength as calculated before for the single span), we

shall find that it will take a weight of more than $5\frac{1}{2}$ tons at the quarter-span to cause an inch deflection, without the chains. In this case, therefore, the resistance of the chains to a small displacement would be about 18 per cent. of that of the girder, and would tend to reduce the wave calculated on the preceding principles by a like per centage. But there is also another consideration to be taken into account, operating the other way. When the rolling load comes on a bridge the added strain will cause the stay-chains to stretch, and this will occasion an increase in the deflection of the bridge. There are thus two causes, one of diminished, the other of increased disturbance, which to some extent counteract one another, and which are not reducible to a general rule, as they vary with the conditions of each bridge. Their operation therefore has to be specially calculated, and allowance made for them, when applying the results of general theory to any particular case.

It must be borne in mind that the displacements we have been investigating are *very small*, consisting of inches, where the span consists of hundreds of feet. The resistance of the chain rapidly increases when the displacements become large enough to cause an appreciable alteration in the rate of curvature of the chain. In this respect the chain has a very different law from the girder. If a load of 50 tons deflect a girder 10 inches, we may expect a deflection of 1 inch for a load of 5 tons. Not so with the partial displacements of a chain. If 50 tons caused a displacement of 20 inches, it would by no means be a just inference that 5 tons would cause a displacement of only 2 inches. Thus, in a model in which the wave is greatly magnified, and especially when there is a large distributed dead load on the platform, the action of the chains in reducing the wave will be proportionately much greater than in the actual bridge. As we have already seen, the wave in Mr. Barlow's model is in each instance less than theory would indicate; and the more so as the stiffness of the girder is reduced, or the distributed dead load increased. The consideration just adduced furnishes a clue to this discrepancy.

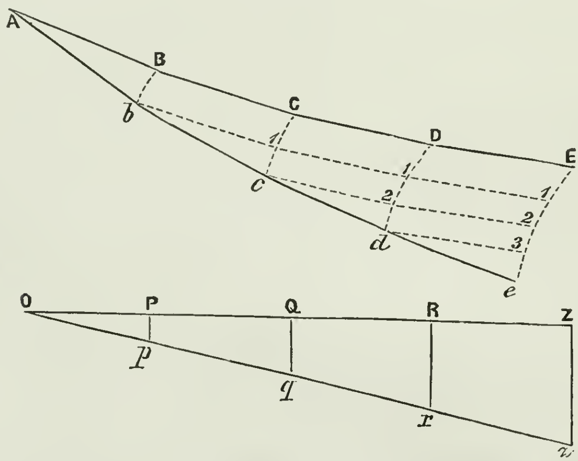
While therefore the strength of the chain is sufficient to carry a load that would prove destructive to the girder, if not suspended, the resistance of the girder to small partial displacements is far more powerful than that of the chain. For the strength of the girder consists in its rigidity; whereas the equilibrium of the chain is dependent on its readily adapting itself to any particular curve required by the distribution of the rolling load at a given moment. The suspended girder, by virtue of its rigidity, transmits a partial load to the chain in the form of an equally distributed pressure. Thus the girder preserves the equilibrium of the curve of the chain, while the chain furnishes the ultimate support of the whole, or nearly the whole, of the load.

It is perhaps due to the reader to explain how we arrive at the general expression for the horizontal displacement resulting from the deflection, or the pulling up, of a chain; the more so, as it forms, in

fact, the basis of the whole of the foregoing investigation. The general expression referred to is $\int \frac{dy}{dx} . dz$, given *ante* p. 318 (293 *Journal*).

In fig. 1, A B C D E represents part of a chain in its original position, and A b c d e is the same chain after displacement; the point A is supposed to be fixed. O Z being a horizontal line, O p q r z is the curve of the vertical displacements of the chain, the ordinate P p being equal to the difference in height between B and b; the ordinate Q q to the difference in height between C and c, and so on. The displacements are supposed to be small, although in the diagram it is necessary to make them large, for the sake of clearness. The length of chain A b is equal to A B, b c to B C, and so on to e. Each length of the chain except A B undergoes at once a change of *place* and a change of *direction.* The change of place is again resolvable into *vertical* displacement, which is already plotted in the ordinates of the curve O z; and *horizontal* displacement, which is what we want to determine, and

Fig. 1.



which is the aggregate effect of the changes of position of the successive lengths of chain. It will assist the understanding if we distinguish between the change of place and the change of direction, by considering them as sucessive instead of simultaneous.

First, then, A B assumes the position A b. The necessary result is a change of position of the remainder of the chain B C D E to b 1 1 1; the points C, D, and E taking a parallel motion equal to B b, as indicated by the dotted lines C 1, &c., so as to produce change of place without change of direction.

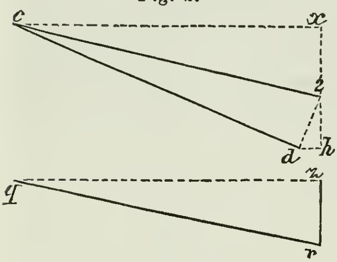
Next, let B C, after moving as we have seen to the position b 1, undergo its change of *direction*, assuming that of b c. C D E will now sustain a second change of place, viz: from 1 1 1 to c 2 2, the dotted lines 1 2 (indicating the path of this movement) being equal and parallel to 1 c.

The next step is for $c\,2$ to fall into its new direction, $c\,d$: this will be attended by a parallel movement of 2 2 to $d\,3$. Lastly, $d\,3$ assumes its ultimate direction, $d\,e$.

By thus laying down the paths, E 1 2 3 e, D 1 2 d, &c., in which the various points in the chain may be supposed to travel to their new positions, it is rendered obvious that the displacement of E, both vertical and horizontal, is the sum of the effects of the changes of *direction* of the several lengths of chain. So that if we find the horizontal movements given by the change of direction of A B, B C, &c., and add them, the sum will be the amount of horizontal displacement at e.

Fig. 2 gives an enlarged view of a length $c\,2$ of the chain, and its movement to its ultimate direction, $c\,d$; $q\,r$ is a corresponding portion of the curve of deflection. x and y being the horizontal and vertical ordinates of the point c, as measured from some fixed centre or origin, $c\,x$ in the diagram will be the differential of x, and $x\,2$ the differential of y: $r\,z$ will be the differential of z, and will be equal to the element ($h\,2$) of vertical displacement.

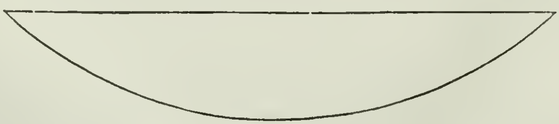
Fig. 2.



If $c\,2\,d$ were a right angle, the right-angled triangles $d\,h\,2$, $2\,x\,c$, would be similar to one another; but as the angle $2\,c\,d$ is supposed to be very small indeed, the error resulting from considering $c\,2\,d$ as a right angle is too small to be of any account. We may therefore regard the triangles $d\,h\,2$, $2\,x\,c$, as absolutely similar. It results from their similarity that $\frac{dh}{h2} = \frac{2x}{xc}$; and therefore $d\,h = \frac{2x}{x\,c} \times h2$. That is to say, the differential of horizontal displacement (dh) is equal to $\frac{\text{differential of } y}{\text{differential of } x} \times$ differential of z. The sum of the horizontal differentials of displacement from A to E (fig. 1) will therefore be equal to $\int \frac{dy}{dx} \,.\, dz$, between the same points; so that this expression gives—with a minute error—the actual horizontal displacement of c.

We add by way of illustration three figures, to a magnified vertical

Fig. 3.



scale. Fig. 3 is the wave of simple deflection which the girder would fall into without the support of the chains, when half the rolling load

was on the bridge. In fig. 4, the dotted curve shows the reflex wave in which the chain (to preserve its continuity) would draw up the girder, were it not for the stretching: the full line shows the *actual* reflex

Fig. 4.

wave, allowing for the stretching. Fig. 5 exhibits the compound wave which results from the simultaneous action of the wave of deflection in fig. 3 and the reflex wave in fig. 4. The dotted line shows the

Fig. 5.

equal rise and depression which would take place if the chains did not stretch: the full line shows the actual result after the settlement of the chains.

We have now accomplished the object proposed in this article, by briefly indicating the steps by which an intelligible and consistent theory of the suspended girder may be arrived at; comparing its results with those obtained by Mr. Barlow from his experimental model; and pointing out those practical conclusions which seem most obvious or most important. We refrain from inquiring into the sufficiency of the girder proposed by Mr. Barlow for the multiple span bridge at Londonderry, as such inquiry would not come within our present scope. The application of the principles attempted to be laid down to the examination of this or any similar case would, however, be very readily made, provided the section of the intended girder were given. The conclusion that immediately concerns us is the practicability of the suspended girder for railway bridges of heavy spans; the marked economy, moderate deflection, and perfect safety of bridges constructed on this plan; and the proportions and other conditions to be observed. Experiment and theory have now done their part. Each involve some known, and possibly also some unsuspected, sources of error. It remains for the practical engineer, by the bold test of some actual work, at once to correct and verify the conclusions of abstract science, and remove the question for ever from the province of discussion.

PROCEEDINGS OF THE BRITISH ASSOCIATION.

From the Lond. Athenæum, Sept., 1861.

Section G.—*Mechanical Science.*

Dr. Eddy read "A Proposal for a Class of Gunboats capable of engaging Armor-plated Ships at Sea, accompanied with Suggestions for fastening on Armor-plates." He considered that the monster iron-clad vessels which we and our neighbors were building, might be successfully assailed by vessels of very inferior size specially

designed for the purpose. The first essential condition of such vessels was superiority of speed, and so protected as to approach them without being crippled: and he believed that one such vessel with a couple of heavy guns might so harass a larger vessel as to paralyze her movements, and that two such vessels might even engage with advantage; and, if this was so, might not a flotilla of these small vessels advantageously engage a fleet of the large iron-plated ships? To obtain superior speed, we must either sacrifice weight of metal or increase the size. He preferred the former, and by reducing the armament to a very few guns—two or four—and those of the powerful kind now manufactured, he thought we might obtain the required speed within moderate dimensions; and he hoped to show that, by a peculiar adjustment of material, we might gain all the protection required, without immoderate weight. Much of this problem had indeed been worked out by Captain Coles, of whose cupola, the conical fort, with revolving shield, in the model produced, was a modification. A speed of sixteen knots an hour would, he believed, be sufficient for present purposes, and he took it that this speed might be secured without difficulty in a vessel of fine lines, and of certain proportions, without tremendous size. Dr. Eddy proceeded to describe from a model the kind of gunboat he proposed to build. The dimensions, he said, were calculated from one datum, namely, the least elevation above water at which the guns could advantageously be laid, which he took to be 8 feet. In this position, then, he would place two of the heaviest Armstrong guns, with their muzzles 4½ feet apart, on an inclined slide, upon a turn-table placed within a fixed conical fort, armor clad, the sides of which sloped at an angle of 45°. Above this, for a perpendicular height of 4 feet, he would protect the guns and gunners with a shield of iron plate, also at an angle of 45°. The shape of the fort would be a truncated cone on a cylinder, like an extinguisher upon a candlestick. A second cupola he believed, might be added, and this would give an armament of four guns, which, if concentrated upon one point at short range, must have a crushing effect. But, to be of any use, the smaller vessel must be enabled to approach her large antagonist without risk of having a shot sent through her bottom from the enemy's depressed guns. The manner in which he proposed to fortify the gunboat, was by keeping all the vital parts well below the water-line, and covering them with a deck which would deflect upwards any shot that might reach it. As the boat was only intended to attack ships, not forts, he presumed there was no need to apprehend a shot striking her at a larger angle with the horizon than 7°. Still at this angle, to protect the sides of the vessel effectually, the armor must be carried at least 4 feet above water, and 3 feet below, possibly more; but as this involved a weight of 300 tons in plating alone, some other method of protection must be sought. He hoped he had found this desideratum in a plan which aimed at carrying out thoroughly the principle of deflection. His plan consisted of an arched deck of inch iron resting upon two courses of timber, the extremities of the arch being tied, so as to neutralize the outward thrust. He pro-

posed that this should spring at the sides from three feet below the water-line, and that the crown should rise amidships up to the water-line, the crown being kept tolerably flat, the object being to present so small an angle that even a flat-headed bolt should glance off. The space above the deck and between it and the water-line he proposed to pack with some tough and resilient but light fibre, and these qualities he found combined in the cocoa-nut fibre, which could be easily rendered incombustible by sal-ammoniac. This fibre would offer a considerable amount of resistance to the penetration of a shot, and in proportion to the resistance would tend to deflect the shot. The exact amount of resistance which this mode of packing would afford could not be ascertained without experiment, but the trial would not be expensive. He might be met with the objection, that steel or iron was the substance which offered the greatest amount of protection proportionate to its weight. Granting this, he maintained that there were circumstances under which iron alone could not be advantageously used, and that this was one. Dr. Eddy alluded to the difficulty now felt in securing the iron plates on the sides of the vessels without weakening them by perforating holes, and he mentioned a plan of screwing the plates within a rail-shaped frame, which he said he had been encouraged by Mr. Fairbairn to lay before the Section, and which he thought would obviate the difficulty.

Capt. Blakely, R. A., then brought forward his paper "On Artillery *versus* Armor."—He said it was now four years since he first developed at Dublin his ideas with reference to the strength and extent of range which might be obtained with a particular description of cannon. He was happy to think that the principle he then contended for had since been recognised by both the English and Spanish governments to be correct. With great deference to the opinion of Sir William Armstrong, he must state, as the result of his experiments, that nearly every kind of steel he had used was better than every kind of wrought iron. Cast iron, where weight was no objection, he found to answer admirably. Capt. Blakely exhibited the drawing of the new Spanish gun, and explained its construction. The diameter of the bore was between six and seven inches; more than half of the gun, he said, was of cast iron, the upper portion of the breech only being formed of rings of steel. Extensive experiments had been made to determine the proper degree of tension for these rings, because on that point depended the efficiency of the gun. If the rings were too tight, they burst before the central part; and if they were too loose, the central parts burst first, and perhaps left the rings whole. He did not think that any limit could be assigned as to the size which would be reached in the manufacture of guns. The whole question of armor hung on the cannon which it had to resist. He had read that Sir W. Armstrong was engaged in the manufacture of a 300 ℔. gun. He (Capt. Blakely) was trying to make a 600 ℔. pound gun, and by using wire he did not think there was any insurmountable difficulty in making a 6000 ℔. gun, or even a 60,000 ℔. gun. He believed it could be

done, and if it could be done any where it was in England. The construction he would propose was that to which Sir William Armstrong alluded and approved of on the previous day, the coiling of steel wire round a central cylinder. With a 600 ℔. gun of this construction the iron plates would have no chance.

The Chairman remarked that they had better confine their attention to the 200 ℔. gun, which was all they had got at present.

Capt. Blakely admitted that with the 200 ℔. gun the iron plates would have the best of it. He had offered over and over again to make a gun of the description he had named at his own expense, and place it at the service of the government for trial, and the offer had been refused. With all respect, he must remark that it was not philosophical for the government to refuse his oft-repeated offer, and to go on building ships with the conviction that such guns could not be made. He, however, announced that since the last meeting of the Association the Ordnance Select Committee had acknowledged the correctness of his theory that in building up cannon each layer must have a definite strain; he therefore asked the meeting to place some confidence in his assurance that guns could and would be made to smash any armor-plate which a ship could carry.

Mr. Fairbairn, President of the Association, as one of the Committee (of which Sir J. D. Hay was chairman) appointed to conduct the experiments at Shoeburyness, gave some of the results of the experiments made. Apologizing for his not having been able to prepare a written report, he stated that one of the results of the experiments made was to convince him that, though we had very good iron in this country, yet he did not think that the quality of the wrought iron was quite so good as some produced in other countries. The iron itself was good, but it had not that uniformity of texture which was obtained in foreign countries. Our iron-masters, he believed, were bestowing attention on the subject, and in a short space of time would, he believed, be able to produce such plates as would have a fair chance of resisting such artillery as Sir William Armstrong's. It was the intention of the Committee to do every thing they could to resist Sir William Armstrong, and he on his part would of course do every thing he could to smash them up. In the case of armor-plated ships, it was not only necessary to have plates of sufficient thickness, but to have sufficient resistance behind to resist the deflection caused by the shot. In the *Warrior* and the *Black Prince* wood was used for this purpose. His own opinion was, that wood was entirely unnecessary, and that every part of the vessel above the water-line would be better of iron. Experiments had been made to test the velocity of the shot from the Armstrong gun, and it was found to be about 1100 feet per second. Mr. Fairbairn referred to the necessity of securing toughness and homogeneousness in the plates, and also the desirability of securing a better mode of attachment than the present system of using bolts or screws. They had tried experiments with a target composed of iron bars; but they found that the resistance offered was not nearly so great as by the iron plates. The experiments would be continued, and

in a few months the Committee hoped to arrive at a definite result with regard to the proper thickness of the plates, the mode of attachment, and the quality of the iron.

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"On the Iron-cased Ships of the British Admiralty," by E. J. Reed.—He enumerated and described the vessels at present constructed; and stated that the construction of six other vessels had been determined upon, the contracts for three of this number having already been issued. It was important to observe that, notwithstanding the long delay on the part of the Admiralty before they commenced the construction of vessels of this class, the determination of Parliament to have a fleet of iron-cased ships had even now overtaken the Admiralty, and no experiments on a large scale had yet taken place. The great expense it would be necessary to incur to conduct target experiments on a large scale had probably much to do with the delay. A committee of eminent ship-builders had lately estimated that the cost of a target large enough to test half a dozen modes of construction would be no less than £45,000, and another £45,000 would have to be expended in the construction of a floating hull on which to place the target. The three new ships in course of construction would be 20 feet longer than the *Warrior*, 15 inches broader, 582 tons additional burthen, and 1245 tons additional displacement; and as the displacement was the actual measure of the ship's size, they would thus be more than 1000 tons larger than the *Warrior*. As the engines of the new vessels were only to be of the same power, their speed would probably be much less than that of the *Warrior*. This diminished speed was one of the penalties we must pay for clothing both extremities of the vessel with iron plates. Another penalty would probably be a great tendency to chop and plunge in a sea-way. The cost of these new vessels would exceed the cost of those of the *Warrior* class by £20,000 or £30,000. They would certainly be noble specimens of war ships. A vessel built throughout of iron, 400 ft. long and nearly 60 ft. broad, enveloped from end to end in armor impervious to all shell and to nearly all shot, furnished with the most powerful ordnance, with ports 9 ft. 6 ins. above the water-line, steaming at a rate of 12 or 13 knots an hour, would indeed prove a most formidable engine of destruction. If the present intentions of the Admiralty were carried out, we should have six of such vessels added to the navy in the next year or two. In vessels of this kind all beautifying devices must be dispensed with. Their stems were to be upright, or nearly so, without that forward reach, the "knee of the head," which added so much to the beauty of the present vessels. Their sterns would also be upright, and as devoid of adornment as the bows. It should also be stated, as a distinguishing mark of these six ships, that their thick plate would not be extended to the bow at the upper part, but would stop at the junction with the transverse plated bulkhead, some little distance from the stem, and this bulkhead would rise to a sufficient height to prevent the spar deck from being raked by shot. They would be armed with fifty 100-pounder Armstrong guns, forty on the main deck and ten on the upper. It was

not yet determined, he believed, whether these new ships were to be backed up with teak, as in the previous ships, or whether the plates should be 6½ inches thick, without wood. This would not be decided upon until after the termination of the experiments with the large targets suggested by the President and others. All that was yet definitely determined was, that whether the armor be made of iron alone or of iron and wood, its weight should be equal to iron plates 6½ ins. thick. He now came to notice a very different class of vessels, of which the hull was mainly timber with armor plated upon it. The *Royal Alfred*, *Royal Oak*, *Caledonia*, *Ocean*, and *Triumph* were all vessels of this class. Their length was to be 272 feet, breadth 58 feet, and displacement 6839 tons. Each would be fitted with engines of 1000 horse power. They were formed with timber originally designed for wooden line-of-battle ships, but had been lengthened 18 feet. The whole of these ships, it was believed, as well as the iron-plated ships, would match *La Gloire* in speed, provided they were fitted with the engines at first proposed. It was necessary to make this proviso, because there was a probability of smaller engines being put into some of them. He could not pretend to compare the French and English ships with each other in detail; but he might mention that a friend of his, who had just returned from France, had furnished him with the dimensions of the *Solferino*, one of the largest of the French iron-cased ships, as follows:—Length 282 feet, breadth 54 feet, draft of water 26 feet, burthen 6820 tons. The vessel will be plated with 4¾ inch plates, right fore and aft at the water-line, and over two decks amidships. With reference to the cost of iron-plated vessels, Mr. Reed said that, assuming the average cost of the ships to be £50 per ton, and the engines £60 per horse power, then the eighteen ships which we were now building would cost about £4,700,000, and their engines above £1,150,000—together nearly £6,000,000 sterling; and when masted, rigged, and fully equipped, £8,000,000 would have been expended upon them. He referred, in conclusion, to the extensive dock changes which this revolution in ship-building rendered necessary, and urged the serious importance of at once supplying increased dock accommodation in the South of England for these ships. He argued that whether in peace or in war such accommodation would be required; that it would be in the highest degree perilous longer to defer the establishment of colossal docks on the Southampton Water, and in some other favorable places. At present we had no docks fitted in all respects to receive such ships, whereas the French had many. Mr. Reed contrasted the English and French docks; and stated that it had been proposed to increase the French works by the establishment of an immense steam arsenal, protected by a series of impregnable fortresses at Lezardrieux.

A vote of thanks to the readers of the papers, proposed by the Chairman, was carried by acclamation.

Sir J. D. Hay rose, at the request of the President of the Association, to supplement his remarks on the Experiments at Shoeburyness with some observations of his own. The Committee, he said, in order

to ascertain the best quality of material, the best thickness of metal, and the best mode of manufacturing iron plates, invited the leading manufacturers of the country to place before them specimens of iron plates which they considered best adapted for the purposes required. Plates varying in thickness from ¼-inch to 10 inches were sent in. The Committee found on making experiments, that the steely description of metal, that is to say, metal which had been hardened, and went by the names of semi-steel, homogeneous iron, &c., up to a thickness of ¾-inch, possessed great resisting powers, but after that thickness, this description of metal was not so well qualified to resist a blow of a projectile as wrought iron of the best kind. This having been ascertained, another law had been pointed out to them which they were not yet in a position fully to recognise. It was that the resistance of the plating increased with the square of its thickness. Thus, if the resistance of a plate 1 inch in thickness was equal to 1, the resistance of a plate 2 inches in thickness would be 4; 4 inches in thickness 16; and 6 inches in thickness, 36. Considerable difficulty was felt in fastening the plates upon the sides of the vessels, as it was felt that all holes drilled in them were a source of weakness. Mr. Scott Russell had a plan of fastening the plates, which, perhaps, he would explain to the meeting. Their great fear was not of a solid missile being driven through the ships sides, but of the possible materials the shot might contain. They could scarcely hope effectually to exclude cold shot, but they did think it was possible so to construct a ship and so to plate it, that a hollow missile impinging upon its sides would be broken to pieces, and consequently they hoped to be able to exclude all shells, red-hot shot, and shot filled with liquid iron, which were amongst the most terrible weapons of modern warfare. In the course of their experiments they had tried the effect of the shells upon an old brig, the *Hussar*. At the twelfth round the brig was on fire beyond the possibility of extinction. He thought it a misfortune that the stem and stern of the *Warrior* were not better protected—and the steering apparatus was placed in that part of the ship from which the missiles were scarcely excluded at all. He thought it a wise determination on the part of the Admiralty to convert the wooden line-of-battle ships laid down into armor-plated vessels of great size and speed. In the course of the Shoeburyness experiments they had found that at whatever angle the targets were placed, the fracture made by the Armstrong gun was just as large, though it differed somewhat in shape, according to the angle. He could only account for this fact by supposing that the damage was done by the instantaneous concussion, and not by the shot boring or punching a hole through.

Mr. T. Aston read a paper "On Elongated Projectiles for Rifled Fire-arms."—After alluding to the improvements that have been made in war projectiles, which have resulted in the elongated form, he proceeded to notice the advantages which it possesses over the old spherical shape. The elongated projectile, presenting to the resisting atmosphere a sectional area considerably less than the sphe-

rical of the same weight, is less retarded in its progress through the air. It follows, therefore, that although the spherical projectile with a similar charge of gunpowder is more easily set in motion, and has a greater initial velocity than the elongated form, and to that extent has at the outset an advantage, the elongated form is much better able to overcome the resistance of the atmosphere, and owing to its superiority of momentum preserves its progressive power for a much longer period, at the same time it is less disturbed by the varying conditions of the elastic medium through which it is propelled. In short, it has a longer and truer flight. The essential condition to the efficiency of the long projectile is, that it shall move onward with its point foremost; if it turns over in its path, it presents a large surface to the action of the air, its flight at once becomes irregular, and is rapidly retarded. The action of the common spinning-top suggests at once the idea that the best mode of making the elongated projectile move steadily through the air with its point foremost is to give it rotation round its axis of progression. The rapid revolution of the body causes its inherent inequalities to be rapidly carried round a constant axis in regular order, and a kind of balance is thereby established, which gives the body a steady motion. Various plans have been from time to time tried with the object of imparting to long projectiles a steady flight; they have been made with spiral grooves cut externally on their periphery, or internally from front to rear, in the expectation that the resisting action of the atmosphere acting on the inclined surfaces would give the requisite spinning motion. Again, they have been made very long and furnished with fins or feathers, in order that they may be propelled on the principle of the arrow, but no practically successful results have as yet brought projectiles of this kind into use. The required object is, as is well known, readily and successfully effected by propelling the elongated projectile from a rifled barrel, that is, a tube having its interior made of such a spiral form that the projectile while it is propelled from the breach to the muzzle is turned round its axis of progression: a rotary motion is thus imparted, which is retained by the advancing projectile and gives it the required steady motion. The elongated bullet was first used with rifled small-arms, either poly-grooved or fluted, or, like the Enfield, having three grooves. The length, however, was limited; and various attempts were made to fire longer projectiles compounded of various metals and of various shapes, so that by changing the position of the centre of gravity they might be propelled point foremost. But if made beyond a certain length, they were always found to turn over at moderately long ranges. Mr. Whitworth was the first to enunciate the principle that projectiles of any requisite length could be successfully fixed by giving them rapid velocity of rotation, which should be increased in proportion with their increased length. He, as is well known, uses rifles having a spiral polygonal bore, in which all the interior surfaces are made effective as rifling surfaces. The success of the elongated projectile having been established in the case of small-arms, their employment with ordnance followed as a natural consequence. Rifled ordnance were, therefore, called into existence to meet

the requirements of the time. In fact, the rifled cannon may be considered as a rifled musket made with enlarged proportions. Directing our attention more particularly to the two systems of Armstrong and Whitworth, we see in the former the coiled barrel and fluted bore formerly used for the rifled small-arm, applied on an enlarged scale. In the Whitworth cannon the same system and form of rifling are used which are employed for the Whitworth musket. There is, however, a change required for the projectiles; they cannot, like the small-arms bullets, be made of lead, for obvious reasons, such as the cost of metal, its liability to distortion of form, and unsuitableness for shells. Sir William Armstrong uses a compound projectile, formed of an iron case surrounded with a leaden coating,—the rifling being effected by the force of the explosion in the barrel, which is thus partly expended in forcing the lead through the grooves. Mr. Whitworth uses a simple hard-metal projectile, made of the requisite shape to fit the rifled bore by machine labor in the manufactory, so that the whole force of the explosion is employed to propel the projectile. After giving a description of the two projectiles, and pointing out that the Armstrong projectile necessarily required a breech-loading cannon, and that the Whitworth is used at pleasure for muzzle-loading or breech-loading cannon, Mr. Aston proceeded to notice the external shape of the projectiles. The importance of giving to ships intended for high speed the shape best suited to facilitate their progress through water is now universally acknowledged; and Mr. Whitworth considered that it was necessary to ascertain, by reasoning upon similar grounds, and by experimental research, what was the proper shape to give to his projectile, so that it might be propelled through the air under conditions most favorable to precision and range. He, after numerous corroborating experiments, decided that the projectile of the form exhibited to the meeting was the best. It has a taper front, having nearly the external section of what mathematicians term the solid of least resistance, the curve being somewhat rounded; the rear is made to taper in such proportion that the air displaced by the front is allowed readily to close in behind upon the inclined surfaces of the rear part. The middle part is left parallel to the required distance, to provide rifling surfaces and obviate windage. The results of long and repeated trials show that this form of projectile gives much greater precision and a superiority of range, varying from 15 to 25 and 30 per cent. (according to the elevation and consequent length of range), as compared with a projectile of the common rounded front and parallel rear end. At low elevations, where the range is comparatively short and the velocities great, the difference in the result of the taper and non-taper rear is not so marked as at the higher elevations, where the mean velocities of the projectiles are reduced. But at all ranges the superiority exists both in precision and velocity, as the elongated projectile at no practical range has a mean velocity so great as to prevent the atmosphere closing in behind it. One of the most important advantages attending the use of the taper rear is, that it gives a lower trajectory, which renders errors in judging distance of minor import-

ance, as the projectile which skims along near to the ground is more likely to hit a mark, especially a moving one, than a projectile which, moving in a more curved path, has to drop, as it were, upon the object aimed at, whose distance therefore must be accurately guessed. The taper shape of the rear is peculiarly well adapted for the proper lubrication of the gun, which is most essential for good shooting. With the Whitworth gun a wad made wholly of lubricating material was introduced; it obviates the necessity of washing out the piece,—and the subsequent adoption of a similar wad for the Armstrong gun enabled that piece also to be used without washing out, which was at first necessary, and found to be a very inconvenient operation for a service gun. Various forms of elongated Whitworth projectiles suited for special purposes were described: tubular projectiles for cutting cores out of soft materials, as the sides of timber ships; flat-fronted hardened projectiles, first used by Whitworth and afterwards by Armstrong, for penetrating iron plates. It is found that these projectiles penetrate, when fixed point blank, through iron plates inclined at an angle of $57\frac{1}{2}°$* to the perpendicular. The edge of the flat front, though slightly rounded, takes a hold, as it were, as soon as it touches the plate, and the resistance met is merely that due to the thickness of plate measured diagonally. Official experimental trials made on board the *Excellent* at Portsmouth showed that these projectiles penetrate readily through water, and would go through a ships side below water-mark. The new American floating battery, which is submerged to protect her sides during action, would find no defence in that plan against these projectiles. Shell and shrapnel having the elongated form and taper rear were also described; and to show the suitableness of that form for ricochet firing, tables were read, from which it appears that the mean results of a series of six shots, making many ricochets within a range of 2400 yards, gave the greatest mean deviation of about 75 yards from the straight line. In considering the probable result of the contest now going on between armor-plates and projectiles, it should be borne in mind that the limit of thickness of armor-plate that can be carried by ships will soon be reached, but that the power of destruction of projectiles may be without doubt increased far beyond what has hitherto been tried. It may, therefore, be reasonably anticipated that in this all-important contest the victory will ultimately rest on the side of the projectile.

Sir W. Armstrong said that, with regard to the prospective size to be attained in the construction of artillery, he must confess he did not go so far as Capt. Blakely. It was quite true that he himself was engaged in the construction of a 300-pounder gun—and the experiment was already very considerably advanced, and so far with perfect success—but, at the same time, he must say he found the construction of even a 300-pounder gun on his principle a work of considerable difficulty, and he really would venture to suggest to Capt. Blakely that it would be better to obtain a 100-pounder or a 200-pounder before he

* Sir J. D. Hay subsequently confirmed Mr. Aston's remarks in this respect, and said that Whitworth flat-fronted shot fired from an Armstrong gun (for the Armor-Plates Committee) had penetrated plates inclined at an angle of 80° to the perpendicular.

ventured upon such a monster as he had mentioned. He agreed with Capt. Blakely that the hooping of a cast iron gun with wrought iron gave it great resisting power ; but he differed from Capt. Blakely in thinking that such mathematical nicety was required in the construction. Provided only care were taken to allow sufficient shrinkage, the hoops would adapt themselves to that amount of tension which would give the maximum resisting force of the gun, and before the hoops would give way the gun would have passed through the phase of greatest resistance. He entirely agreed with Mr. Fairbairn as to the desirability of adopting the form of structure for plated ships which should obviate the use of wood. He attached great importance to this plan, because by adopting it much unnecessary wood would be got rid of, and the iron plates could therefore be thickened, but chiefly because by this means the liability of part of the ship rotting, and their having to pull it to pieces periodically to set it to rights again, was done away with. His opinions on the subject of iron-plated ships had been so often made known that it would be mere repetition for him to go over the ground again. The only new point he had to bring before them was, that in the construction of those ships they must chiefly keep in view their adaptation for a small number of monster guns. There had been a feeling among naval men that guns above a certain weight—five tons, he believed—could not be practically managed on board ship. Lately, however, their ideas had been considerably enlarged, and they now went as far as $7\frac{1}{2}$ tons, which would be about equal to one of his 200-pounders. He believed that guns of a much larger size could be managed, but to do so of course they would have to avail themselves of machinery. Mr. Aston had explained the Whitworth projectile, and had called attention to what he considered it various merits. He had also alluded to his (Sir Wm. Armstrong's), which lay on the table before them. Upon this subject let them talk as long as they liked, Mr. Aston and himself would never come to an agreement. He believed that his own projectile would inflict a greater amount of damage than the other. He thought something more was required than the punching process of the flat-headed shot. Let the effects be tried. Let a target be erected representing an object such as would be used in actual war, and then let experiments be made to see which missile would inflict the largest amount of injury. He had no doubt whatever, that for punching a hole in iron plating the flat-headed bolt invented by Mr. Whitworth was the form, if made of steel. But he apprehended that the object to be attained was not only to punch a hole in the side of an armor-plated ship, but to inflict so much damage as to disable her. What he wanted to effect was to be able to hurl a large mass, no matter what form, against the vessel, so as to crush in her side, and he believed that this could be done by the use of guns of a large size. In the Whitworth projectile, the rotary motion was given by the shape of the bolt. In his own ordnance the projectile was covered with a soft material, and so took the direction of the grooves. There might be advantage in both plans ; but he did claim for his own this superiority, that there was less necessity for precision in the manufacture, and

little fear of injury to the bolt. He had lately been making experiments with a large kind of projectile, one of which he had before him, [a huge mass of metal, weighing some cwt.] In this projectile, instead of having a soft metal all round it, it was confined to three ribs, which would take the impression of the grooves. It was designed for a gun called the "shunt gun," the construction of which, not having a diagram with him, he could not explain.

Mr. J. Scott Russell said, there were one or two general considerations of this subject which he thought, if laid before the meeting, would save a good deal of misapprehension. If they would just set out by believing that we should never get perfect impenetrability, many schemes, with the answers to them, would be put out of the way. The whole practical part was incorporated in one expression of a great sailor, "Whatever you do, for God's sake, keep out the shells." Having been in vessels fired at, and having been behind iron targets fired at, he was in a position to say that he could stand behind iron plating with a wonderful degree of comfort. You were sure the shells would be kept out, and if two or three holes were punched, in the side of the ship by the large shot, neither you nor the vessel were much the worse for it. But if Sir William Armstrong should be able to do as he had just said, to bring large masses to bear upon the sides of these iron-plated ships, then this was another mode of destruction quite as injurious as destruction by shells would be. The whole question then resolved itself into these two things:—Keep out the shells, and prevent Sir William Armstrong driving in the sides. The ship-building question at the present time involved the very difficult problem, how to build a ship with an enormous weight in the place where good shipbuilders generally contrived to keep out all weight. The first vessels were loaded with 1000 tons, the new vessels would have 1500 tons, and this weight was not only a great inconvenience, but a great injury to the sides of the ship. As the ships were now built, the plating in no way contributed to the strength of the ship; he was anxious to see the ship built entirely of iron, in which case iron plating might contribute to the strength. What he wanted to know was, how much in the construction of these large ships the builders might be allowed to appropriate of 9 inches of iron to be used partly in armor, and partly in the construction of the ship? The question they now asked the Iron-Plates Committee, and which he believed Mr. Fairbairn's experiments would settle in a very short and decisive manner, was, how much of this iron could be used in the construction of the ship, and how much must be used in armor-plating outside? Take it that there were eight inches of plating allowed. If the Committee would be content with a 2-inch plate, and a 1-inch plate on the outside, leaving the builders five inches to be used in the sides of the ship, he was prepared to say that this would be an enormous advantage. He would even meet them further, and give them four inches to be used for the armor, leaving him four inches to be used in the construction of the ship. But the Committee might insist upon having a 5-inch plate to go to the bad, leaving him only three inches for the ship, and he would

still endeavor to build the ship to suit these conditions. There was another point upon which the builders were at issue with the Committee. The Committee say they will not have holes in these iron plates, and the builders reply that, so far as they knew at present, the Committee must have holes. Sir J. D. Hay had asked him to lay before the Section a plan which he had submitted to the Admiralty so long ago as 1854. He would bring up between the plates a piece of soft malleable iron. This he would heat in its place after the plates were on, so as to make a round-headed rivet all round the edges of the plates, which could thus be firmly attached. This plan, if successful, would obviate the necessity of perforating the plates; but allow him to say that he did not believe in his own opinion until tried, for there was scarcely a theory promulgated but was knocked down by those Armstrong and Whitworth guns—and at the present moment he had not a single theory to set up. The *Warrior* had been built without armor on her extreme ends, and he (Mr. Scott Russell) had some of the blame or the merit of that arrangement—which it was, remained to be seen. But yet he would take very little credit on that point, for this reason, that when the dimensions and the required speed of a vessel were settled, the question as to whether she should bear armor from end to end was determined beforehand by the very conditions of the problem. Referring to Mr Aston's paper, Mr. Russell entered into calculations to show why he did not attach much importance to the tapering form of the Whitworth projectile. He believed that in proportion as the velocity of the projectile was less than its critical velocity, which he believed was about 1100 feet per second (the very velocity which the Committee had ascertained was the velocity of the Whitworth projectile), in that proportion only might some advantage be derived from distinction of shape. The case of the projectile and the ship differed in this, that the one had attained its critical velocity and the other had not, hence this difference in his opinion with regard to the value of form. In the ship it was of value, but in regard to the projectile which had attained its critical velocity, length and fine taper would have no effect. But this was one of the subjects upon which no wise man would dogmatize, but would be grateful to any one who would institute experiments. Admiral Sir E. Belcher considered that the suggestion of Dr. Eddy, for constructing small vessels to compete with the iron-cased frigates, had been met by Mr. Scott Russell's observations on the incompatibility of weight and speed without dimensions. The height of the large vessel would enable her so to depress her guns that the smaller boat would present an angle of about 60°, instead of the angle stated. The curved deck of the proposed gunboat involved the necessity of its being rendered bomb-proof, and that entailed iron plating equal to the plating of a frigate. The fibre suggested for the packing would be peculiarly liable to smoulder or to burn, and the salt with which it was proposed to render it incombustible would corrode the iron so rapidly that, in the course of a few months, the vessel would be useless. It had occurred to him, that in-

stead of the iron plates being backed up with wood, iron ribs, placed transversely, something in the gridiron fashion, at intervals from each other less than the diameter of the shot, and the interstices filled up with wooden material, would be a better mode of resistance. By the present system of laying the iron plates, if one were injured when the vessel was abroad, it would be impossible to replace it, perhaps for months or even years. Therefore he thought it would have been better if Mr. Scott Russell had followed out his plan of sliding the plates in from the water-line upwards, because if one of the lower plates happened to get injured, it could be removed, and the other plates could be slid down to fill up the vacant space, and a new plate could be put in at the top without difficulty. After the battle of Algiers, it was his duty to clean out the captain's cabin. He was surprised to find that a ream of foolscap, which had been struck by a large shot, had simply been crimped up. In 1854, he applied for leave to build a battery of compressed brown paper, and he believed that this material, which was one of the most powerful repellants of shot, might be advantageously used. Sir E. Belcher alluded to the force with which even wooden ships could charge and split icebergs, and expressed his decided opinion, that if the weight of the *Warrior* struck *La Gloire* across the bows, the latter must inevitably go down. He, himself, if hard put to it, should have no objection to have a try at *La Gloire* in one of the old wooden ships—and he thought he saw some of his naval friends around him who would say the same. He complained that the peculiar construction of the new vessels would deprive them of the pleasure of running down an enemy, which was a point upon which naval men prided themselves.

The Rev. Dr. Robinson (Dean of Armagh) said the paper which had been read by Mr. Reed, could hardly be rated too highly, and he hoped a recommendation would proceed from that Section that it should be printed in the *Transactions*. In the course of an interesting address, Dr. Robinson traced the invention of armor-plates to Lord Rosse; and whilst paying a high tribute to the splendid mechanical genius of Mr. Whitworth, he pointed out that both the elongated projectile and the beautiful system of polygonal rifling were inventions dating much further back than his time. He himself had seen a rifle on the polygonal principle, made two centuries before Mr. Whitworth was born.

Mr. Fairbairn, in allusion to the remarks of Mr. Scott Russell as to the possibility of using a number of single inch plates, instead of one solid plate, stated that the experiments had shown that one 2-inch plate was equal to three or four 1-inch laminated plates. He quite agreed with Admiral Belcher as to the form of the bows of the *Warrior*. His own opinion was, that they should have been curved downwards instead of projecting below.

MECHANICS, PHYSICS, AND CHEMISTRY.

Hydraulic Power.

From the Lond. Mechanics' Magazine, Sept., 1861.

A wonderful example of what hydraulic pressure, acting through suitable machinery, can effect, is seen in the application of what is known as Sir W. Armstrong's hydraulic apparatus at the Swansea Docks. The pipes which convey the water, at a pressure of 700 lbs. to the square inch, extend for a mile and a half; the hydraulic power being available at any point throughout this length. By this agency, rendered so docile as to be almost within the control of a child, though before it the strength of the elephant sinks into insignificance, the gates are opened, the bridges swung, the sluices worked, and all the herculean labors of the docks performed. Man, no longer a mere drudge, exhausting his puny strength in endeavoring to counteract the forces of nature, employs these forces one against the other, and renders them obedient to his will. Mechanical science first taught how power might be gained at the expense of speed: the steam engine and the hydraulic press were an advance beyond this point of compromise, placing unconditionally in the hands of man, a power which can scarcely be calculated as a multiple of a man's work in foot-pounds.

The only important practical objection to the universal employment of the stupendous power of hydraulic pressure wherever it may be made available, is the danger arising from the necessary steam apparatus erected in the vicinity of warehouses; in consequence of which, increased rates of insurance become chargeable. To remedy this objection, it has been proposed to establish central stations for the generation of hydraulic power, and to distribute this by means of mains laid along the principal thoroughfares in proximity to wharves and warehouses, to which the power required for working cranes and hoists, or for any other purpose, would be conveyed by branch pipes. Thus a motive power of any amount, certain in application, and under perfect control, would become available, with the advantage, in point of safety and economy, of dispensing with separate steam power for each establishment.

The full importance of the results which would follow the application of this system, are but partially shown in an arithmetical statement giving the mere pecuniary *saving* in actual hoisting. The speed with which the work can be done, and ships or barges loaded or cleared to make room for others, is a most important element in the calculations of the owners of wharf properties. Under the present system of manual labor applied to cranes and hoists, lifting forty tons through forty feet in twelve hours, by the employment of six men, must be considered a good day's work for the latter. The cost per ton in this case would be between 6d. and 7d.; whereas by hydraulic power, 200 tons could be raised to the same height, in the same time, at a cost of about $1\frac{8}{10}$ths of a penny per ton.

The simple arithmetical statement shows that the cost of the present

system varies from one halfpenny per ton per foot, for a "short lift," to one-sixth of a penny for a "high lift;" this being the actual cost of labor, without taking into calculation the interest of capital invested in machinery. By the application of hydraulic power under the proposed system, the cost of raising one ton one foot high is reduced to ·06d., or about one-sixteenth of a penny; allowance being made *at the rate of twenty-five per cent.*, for the interest of the capital necessary to establish the mains and the entire working machinery. At the Liverpool docks, the comparative expenses of the two systems have been calculated by Mr. Hartley, as bearing the proportion of eight to twenty-two in favor of hydraulic power.

The amount of work performed by the hydraulic crane may be estimated by an inspection of the St. Catherine's Docks; where one crane, of double power, raises from the vessels to the quay, 370 tons in seven working hours. At the Regent's Canal, the coal cranes discharge upwards of 300 tons in ten working hours, raising from seven to eight cwt. of coal at each lift.

There is another point of view in which the project we have alluded to may be regarded, viz: as affording an extremely adequate safeguard against fire. It has already been shown that the advantages which are offered are accompanied by no danger arising from a furnace and steam boiler on the spot where the hydraulic power is to be applied. But in case of emergency from fire, the supply of water under high pressure may readily be made available for its extinction. Recent calamities, which we need not particularize, have sufficiently proved that the class of buildings to which the project applies are peculiarly liable to the devastating action of fire; and at the same time these calamities have rendered evident the inefficiency of the means now at hand to guard against such danger. To obviate inconvenience from any accident to one set of pipes, a double main will be laid to convey the hydraulic power; and to one or both of these a hose connexion will be established at each set of premises using the power. This hose connexion will be kept closed and sealed until such emergency arises, as to render the water supply by this means indispensable.

Those of our readers whom this project specially regards, may be glad to learn that there is every prospect of its speedy accomplishment. The requisite Parliamentary powers were obtained last year for the formation of a company to carry the same into effect. The plan of operation includes, in the first instance, the establishment, on both banks of the Thames, below Blackfriars-bridge, of a sufficient number of cranes, worked by hydraulic pressure, generated by two steam engines placed at central points for that purpose. The facilities which will thus be afforded for the traffic operations on the great river thoroughfare to the metropolis will not fail to be appreciated; and the same facilities will doubtless before long be extended throughout the kingdom. On the part of the offices for insurance against fire, there appears to be every disposition to lower the present rates of insurance for premises in which the proposed means for obtaining motive power and the supply of water under pressure may be adopted.

For the Journal of the Franklin Institute.

Reply to the Criticism of SAMUEL MCELROY, C. E., "*On the Erie Experiments on Steam Expansion by U. S. Naval Engineers.*" By ALBAN C. STIMERS, Chief Engineer, U. S. Navy (one of the Experimenters).

The paper, of which the above quotation is the title, appeared in the October and November numbers of this *Journal*, and is a remarkable example, no less of the looseness with which many engineers read professional papers, than of the great want of analysis they bring to bear upon the subjects of which such papers treat. It is well, perhaps, that such a reader and such a student should have given us the impression which the report of the Board made upon his mind, as he is the representative of a large number in the profession, who exercise in their numerical strength a great influence over the designs and proportions of a large amount of steam machinery. A reply, therefore, to one of them, who has had the boldness, the intelligence, and the literary ability, to come out and attack the report in a first-class magazine, though it may not be a reply in detail to each individual, will at least have the effect of showing them that a closer study of the report itself would answer most of their objections.

The following are some of the principal difficulties under which this writer labors:—

A failure to conceive the real matter which the experiments were intended to assist engineers in deciding.

A failure to separate incidental information, developed in the course of the experiments and generally valuable to engineers, from that which bore directly upon the main question to be decided.

A misconception of what the conditions are in an engine, the change of which will affect the economic result. And finally,

He fails to comprehend many of the simplest arguments, and to perceive that most of his objections are answered in the body of the report itself.

He says, "This is the real matter at issue—whether it is cheaper to carry high steam and expand, or to carry low steam and follow full stroke." He does not appear to be conscious that this mode of regarding the subject unites the question of high pressure with that of expansion; whereas, the experiments were instituted, not to ascertain the relative economy of using steam of different pressures, but "the relative economy of using steam with different measures of expansion." The report states, on page 23, in the very commencement of the "discussion of the results," that, "In examining the preceding two tables, it will be observed that particular care was taken to have the initial cylinder pressure (table 2, line 1) the same in all the experiments, as nearly as practicable, which, with proper area of conduit open in proportion to quantity of steam used in equal time, would necessarily make the boiler pressure equal. In fact, throughout the experiments, the boiler pressure (table 1, line 18) was nearly equal, the difference

being too slight to be of any practicable importance. That this is a proper condition for the purpose of the experiments will be obvious when it is considered that amount of pressure is purely a question of boiler, and not at all one of engine.

"If a given power be required to be developed by the same piston, working at a given speed, but with different measures of expansion for the steam, it is plain that the initial pressure must be increased as the steam is used more expansively, and the condition of equality of initial pressure could not obtain. This, however, would only be unnecessarily employing too large a cylinder when the steam was used less expansively; or, in other words, it would be an engineering blunder. The proper method is—for equality of power and of initial pressure—to proportion the cylinder to the measure of expansion adopted for the steam, making its capacity for equal speed of piston inversely (table 2, line 22) as the net effective pressures upon the piston (table 2, line 7).

"From the justness of these premises there is no escape, and it is preposterous to base a claim of economy for large measures of expansion, not upon the expansion *per se*, but upon higher initial pressure, when that same pressure can be employed just as easily and well when using steam without expansion, if the cylinder be properly proportioned to the work. Therefore, in making a set of experiments to determine the *practical* economic results of using steam with different measures of expansion, it is an *essential* condition that the initial cylinder pressure be maintained the same in all cases.

"It is now proper to give the reasons why a high initial pressure is desirable in view of the economical production of the power. And, first, of the generation of the steam.

"As the dynamic effect of a given weight of steam increases in a higher ratio than the heat required to evaporate it—owing to the accompanying increase in the temperature of the steam—it is obviously desirable to use it in the cylinder at the maximum pressure throughout the entire stroke. We say *use* it in the cylinder, for the economy in function of pressure *per se* attaches to the pressure under which the steam is used, and not to that under which it is generated, because its dynamic effect is developed during its use in the cylinder, and not during its generation in the boiler. Now, it is plain that, starting with the same initial cylinder pressure, the steam will be used with the highest pressure throughout the stroke of the piston when it is used without expansion; and the more it is expanded, the more is the pressure reduced in the cylinder, and the advantage lost that attaches to higher pressure *per se*. This is one *practical* point of gain for smaller measures of expansion over larger ones—a point entirely ignored when the problem is merely theoretically considered, but which must be included in a practical determination; because it is an inseparable function of the physical laws of steam."

The careful reader will observe as very prominent in the foregoing quotation from the report of the Board, that they were not endeavoring to ascertain how much it was desirable to expand the steam in

existing engines, but in those which were yet to be built, and in which proportions could be given that would do the required work in the most economical manner; that the question of expansion, as separated completely from that of boiler pressure, was the subject of investigation; and that they recognised fully and stated clearly the advantages of high pressure steam.

This writer discusses the rate of combustion in the furnaces, the evaporation per pound of coal, the pounds of coal per hour per horse power, the order in point of time in which the different experiments were tried, the speed of the piston, the amount of steam used in a given time, &c., &c. If these questions affected the economic result as properly ascertained by accurate measures, it would be very proper for him to discuss and criticize them; but he does not even attempt to show that they influence in the slightest degree the only measure of the cost of the power developed by the engine, which was pronounced as the only correct one by the Board. They state, page 31 of the report,—

"With regard to the cost of steam power, there are three different measures in use, all of which will be found employed in table No. 1: namely, the weight of the coal; the weight of the combustible; and the weight of water, by tank measurement, consumed per hour per horse power. The last alone is employed in table No. 2. Of these, the first is the least exact; the second is more exact than the first, because it eliminates the ashes, the amount of which is an accidental quantity; but the last eliminates everything connected with the generation of the steam, and is, therefore, critically exact, and should be accepted as the true, universal, and only measure of the cost of the dynamic effect, *per se*, produced by the steam in the cylinder."

It will be perceived that, with this measure accurately applied, it would add nothing to the reader's information upon the subject under discussion, "to have known precisely the times and manner of coal supply, tank supply, cleaning fires, starting and hauling fires, variations of pressure, and the like, as to the boilers."

To show that the Board recognised fully the effect upon the evaporative powers of the coal, of the change in condition to which it was necessary to subject that part of the apparatus in order that the essential one should remain unchanged, I quote from the report what immediately follows the above explanation of the true measure of *engine* economy.

"The weight of coal, under the most favorable circumstances, can only be considered as an indirect and comparative measure of the weight of steam consumed; but, even comparatively, it is not exact unless all the conditions of boiler and coal continue precisely the same, which is a manifest impossibility, as the calorific effect obtained from the coal varies with the skill and care of the fireman; with the quantity of water mechanically present in it; with the temperature of the air entering the ash-pit; with the rapidity of the combustion; with the thickness of the fuel on the grates; with the hygrometric and barometric conditions of the atmosphere; with the more or less copi-

ous supply of air to the furnaces; with the temperature of steam in the boilers; and with the per centum of refuse obtained from the coal; not to include the uncertainty in the determination of the precise weight of coal which generated the steam used in the engine."

The intelligent reader will observe, then, that all the long drawn-out discussions of this writer about the rate of combustion; the use of different coals with their attendant differences in per centa of ashes, &c., and their different evaporative powers, are all thrown away. All that is merely incidental information, and does not affect the question of "the relative economy of the use of steam with different measures of expansion" in the slightest degree, when the economy of each of those measures is determined by the amount of water required to be evaporated per hour per horse power. As it is true, however, that a doubt of the propriety with which any of the information given, even though only incidental, was obtained, would throw a doubt over the whole report, it is proper to reply to some of the principal objections which he has brought against the coal account. It must not, however, be forgotten that the primary objects of the experiments were not to be interfered with in order that engineers might know exactly the evaporative power either of the coals or the boilers used. The Board very naturally expected that there should exist in the profession generally, sufficient sagacity to perceive this and consider the incidental results shown, in close connexion with the conditions under which they were obtained; all of which are fully described in the report.

He tells us that, though in the text the Board claims that "In commencing an experiment, the engine was operated for several hours to adjust it to the normal conditions required to be uniformly maintained during that experiment, and to bring the fires to steady action," the tabulated record shows that, in one case, there was no interval at all, and in two others, only two hours.

In the case of there being no interval, there was nothing to be changed, except the damper in the smoke-pipe, and the point of cutting off. It probably took *one second* to change the former, and *ten* the latter. The other changes upon which he dwells, were simply the immediate results of those two simple movements. The general statement in the text is perfectly true as a general statement intended to cover the experiments as a whole. The above happens to be an exception when it was not required to sweep the flues, change the kind of coal used, or to add to or remove from the wheels any paddles. As for the two instances of there being but two hours between two of the experiments, it must be a very firm position that it is necessary to assail by drawing the nice distinction between the general statement of "several" and the particular one of "two," occurring twice out of six times.

With regard to estimating the "efficient" amount of coal in the furnaces at the commencement and at the end of the experiments, the Board considered that in obtaining the number of pounds of coal per hour per square foot of grate; the number of pounds of water evaporated per pound of coal; or the number of pounds of coal per

hour per horse power, the last decimal place given would not be affected by any error it would make in this estimate, as each experiment was continued sufficiently long to reduce such errors beyond any change in the third decimal figure. The results as given are, therefore, mathematically accurate to that decimal, notwithstanding possible errors in such estimates.

He endeavors to make a point of the difference in the per centum of refuse obtained from the different coals used. He does not appear to be aware that different coals may contain different amounts of noncombustible material, or that different cargoes of coal from the same mine cannot be expected to contain precisely the same per centum of refuse.

It is not necessary to follow him further in his remarks about the coal. Enough has already been written to show that his positions upon it are untenable, and to refute each detail would only add to the length of this paper without increasing its force.

With regard to the corrections of the back pressures in the cylinder to the uniform one of 2·7 lbs. made in table No. 2, he says:—

"There is a difference of vacuum against No. 2, which we do not find credited. Experiment No. 7 ($\frac{11}{12}$ths) shows an average back-pressure in the cylinder of 4·2 lbs., while No. 2 shows but 2·8 lbs. In all these trials, it appears that expansion reduces back pressure by a descending series, except a change in No. 7.* But without accepting this *experimentum crucis* of the condensation argument, the Board decides that back-pressure must be assumed at a common standard, which it accordingly takes at 2·7 lbs. from No. 3. Consequently, the mean pressure of No. 2, which is 13·6 lbs., is to be charged with the standard of 2·7, while that of No. 6, at 29·8 lbs., is credited with the difference between 4·2 and 2·7. This varies the relative horse power, and is highly creditable to the treatment of the questions at issue."

The Board made out one table as the experiments progressed, containing, complete, the exact experimental determinations; but although this is given in the report, it was considered that it would be more complete for the purposes of correct comparison, if differences, obviously due to accidental circumstances, could be eliminated. Upon this subject the report states:—

"The quantities given in table No. 1 are the precise ones obtained by experiment; but some of them require to be slightly corrected, for the purpose of making exact comparisons. The quantities to be corrected are only those of the mean gross effective pressure on the piston, and back pressure against it, (table No. 1, lines 22 and 23,) together with those of the mean gross effective, total, and net horse power depending on them (table No. 1, lines 24, 25, and 26). These corrections are made necessary by the fact of the inequality of the back pressure during the experiments; but, as it was caused by such accidental circumstances as air leakages, different proportion of cylinder steam-port to weight of steam discharged at the end of the stroke of

* He has evidently become confused in his numbering of the experiments, and intends here the one cutting off at 4-45ths.

the piston, and different speed of piston, all of which can be made the same and the back pressure rendered equal, it is necessary for a proper comparison to make the back pressure the same in all the experiments, and to rectify the mean gross effective and net pressures on the piston in accordance with this equality. This has been done in table No. 2, which contains, in addition, all the other data and calculated results requisite to a complete determination of the relative economy due to the different measures of expansion."

It will be observed in this quotation from the report, how completely the Board sank all considerations of existing engines in their search for the true principles which should govern future constructions, and as the amount of back pressure is dependent entirely upon freedom from air leakages, area of exhaust passages, and condenser and air pump capacity, all of which, in every well proportioned engine, are designed with reference to weight of steam used in a given time, and not with reference to size of cylinder, nothing can be more proper than to assume that it shall be uniform. It was obviously impossible to have it uniform experimentally without changing the structure of the engine used for the experiments; but it was considered that a matter so self-evident would only require that a proper quantity should be taken as the standard for all. It was determined to take the smallest that was experimentally obtained in any one trial; this was 2·7 lbs., and occurred in the experiment in which the steam was cut off at $\frac{1}{4}$th.

Now this writer complains that in the trial which expanded the least ($\frac{11}{12}$ths) the mean pressure obtained by experiment is credited with the difference between the 4·2 lbs. back pressure obtained by experiment and the 2·7 lbs. taken as the standard; while the trial which cut off at $\frac{1}{6}$th has only the difference between 2·8 lbs., obtained by experiment, and the same standard of 2·7 lbs. That is, according to him, the Board gave the $\frac{11}{12}$ths trial an advantage of 1·4 lbs. per square inch in the final comparisons. To many people it will appear quite clear that taking the lowest back pressure obtained experimentally as the standard was giving the greater measure of expansion all the advantage it could claim, as with equal initial pressures the greater the measure of expansion the less is the mean total pressure. To make it clear to every one, however, let us suppose that the highest back pressure experimentally obtained (4·2 lbs.) be taken as the standard, instead of the lowest (2·7 lbs.), and observe the difference in the comparative economy.

	As per table.		Supposed case.	
Point of cutting off, ...	$\frac{11}{12}$	$\frac{1}{6}$	$\frac{11}{12}$	$\frac{1}{6}$
Mean total pressure, ...	34·0	16·4	34·0	16·4
Mean net pressure, ...	29·2	11·6	27·7	10·1
Per centum which the latter is of the former, .	85·9	70·7	81·5	61·6
Relative net pressures between the different points of cutting off, ...	1·000	·822	1·000	·756

The greater measure of expansion would therefore lose

$\left(100 - \frac{\cdot 756 \times 100}{\cdot 822} = \right)$ 8 per cent. if calculated as desired by this critic, instead of by the method adopted by the Board.

When this writer comes to the subject of the friction of the engines, he does not appear to understand that the friction of the load, varying directly as the load, may be considered as a part of it in all calculations for comparison between different trials with the same engine. It was only the friction caused by the gravity of the different parts of the engine that the Board considered constant, that is, that it required a constant pressure to overcome. So that, instead of controverting "Morin, Weisbach, and others," it was upon the general principles laid down by them, and experimentally found strictly applicable to the steam engine a few years ago by two naval engineers, that the Board proceeded.

With regard to reducing the size of the engine when the measure of expansion is reduced, he tells us that only the diameter of the cylinder would be reduced, all other parts remaining precisely the same; but it is well understood by all good designers of steam engines, that all the parts through which the power of the steam is transmitted must be proportionable to the initial pressure upon the area of the piston. With the given initial pressure, therefore, the larger piston, required when using larger measures of expansion, requires also larger piston-rods, cross-heads, connecting-rods, beams, cranks, shafts, pillow-blocks, engine frames, bed-plates, &c., &c.—condenser, pumps, pipes, and valves being the only parts that undergo no change.

In remarking upon the fact that engineers were aware before the trial of these experiments that there was a loss by steam leakages and condensation, he states:

"So fully, in fact, are engineers advised on this point, that when any experiment is presented to them, no matter by whom conducted, which claims to have found but 2·91 per cent. loss between the tank and indicator, they respectfully deny its accuracy. It is impossible to avoid a greater loss in the boiler itself, and between the boiler and steam chest, and at the valves as well as in the cylinder."

The steamer *Michigan*, in which these experiments were made, had been out of commission twelve months, during which time new boilers were put in and the engines thoroughly overhauled by one of the most experienced and careful engineers in the naval service; and, in addition to this, the Board spent two weeks in preparing everything for the experiments, taking especial care to prevent the possibility of leakage. With regard to leakage from the boilers, the report states:

"The only outlet from the boilers was through the blow-off valve. Any leakage to occur here had first to pass the blow-off valve, and next the stop-cock placed in advance of the Kingston valve. The blow-off pipe, its valves and cocks were frequently examined during the experiments, and the undersigned are certain there was no leakage from the boilers. The boilers themselves were quite new, and double

riveted; they were so tight that the water would stand in the glass gauges without appreciable fall for days."

It is considered that there will be little difficulty among engineers about choosing in which of the above explanations and assertions they will place their confidence.

His illustrations of losses by leakage and condensation, immediately following the above quotation from his paper, do not require recapitulation, as their errors are certainly too evident to deceive any reader of this *Journal.*

He complains that the notes of the experiments are omitted in the report. It would be interesting to know of what possible use it would be to engineers to have placed before them 21 pages of tabular record and the engravings of 1008 indicator diagrams. Why does he not ask for a verbatim report of all the discussions which took place daily between the members of the Board, while the report was being elaborated and written?

He concludes his paper with an elucidation of "a certain mechanical principle," which speculative engineers of slight practical experience sometimes indulge themselves in dreaming about. The "principle" being that, as the inertia of the mass—the motion of which is accelerated during the first half of the stroke and retarded during the last half—absorbs a portion of the power of the steam while being accelerated, and returns it again while being retarded, the engine will work more smoothly and properly when cutting off at less than half stroke than when following beyond that point. A little practical experience soon dispels all this kind of visionary speculation. He must certainly admit that the difficulty he predicts for an engine cutting off at a point beyond the half stroke would increase with an increase of the speed of piston. Now, it so happens that the present writer took a trip only a few days ago from New York to Amboy, N. J., and return, in the steamboat *Richard Stockton*, for the express purpose of observing the operation of her steam machinery, accompanied by the engineer who designed it. The engine is the ordinary over-head beam, and was built in 1852. The cylinder is 48 inches diameter by 12 feet stroke of piston. The average revolutions during the above trip were 27 per minute, equal to a speed of piston of 648 feet per minute, and I was informed that it had been driven at the rate of 31 revolutions, or 744 feet per minute. Probably this speed of piston is not exceeded, if equalled, by any engine of equal dimension, and it certainly worked with remarkable smoothness and regularity, yet it was cutting off at *three-fourths* the stroke from the commencement. The designer of the engine explained why he followed so far by saying, that the engine was being driven so fast it was impossible to make it work smoothly and regularly when cutting off at any shorter point in the stroke.

In treating the above subject, he accuses the present writer of historical mistakes in publishing an abstract of the report in the April number of this *Journal.* To this it is only necessary to reply, that the historical statements were gathered from standard works upon the history of the steam engine, and will naturally stand as true until *proven* incorrect.

In conclusion, I would remark that it is seldom that a report of 38 pages of printed matter, giving the results of an extensive set of experiments upon an important subject, has not some point so weak that it may be successfully assailed; and if the paper to which this is a reply is the heaviest artillery that can be brought against it, the Board have abundant reason for congratulation that they have been so successful.

To Check the Warping of Planks.

The face of the planks should be cut in the direction which lay from east to west as the tree stood. If this be done, the planks will warp much less than in the opposite direction. The strongest side of a piece of timber is that which in its natural position faced the north.—*Dingler's Polytech. Jour. Bull. Soc. d'Encour. pour l'Indus. Nation.*

For the Journal of the Franklin Institute.

Resistance of Wrought Iron Tubes to External and Internal Pressure. Deduced from Experiments of W. Fairbairn.

By Chas. H. Haswell, C. E.

(Continued from page 306.)

No. 2.

Resistance of Wrought Iron Clylindrical Tubes to Internal Pressure.

Taking the mean of the results of Experiments 31 and 34 on iron tubes,

$$p = \frac{p' \times d}{2\,t}, \text{ or } \frac{425 \times 6}{2 \times \cdot 043} = 29{,}651 \textit{ lbs.},$$

$$\text{and } \frac{2\,t \times p}{p'} = d, \text{ or, } \frac{2 \times \cdot 043 \times 29{,}651}{425} = 6 \textit{ ins.},$$

$$\text{and } \frac{p \times 2\,t}{d} = p'.$$

Hence, *To ascertain the Thickness of a Wrought Iron riveted Tube or Flue, the Diameter of the tube and the Pressure in pounds per square inch being given.*

Rule.—Multiply the pressure in pounds per square inch, by the diameter of the tube in inches, and divide the product by twice the tensile resistance of the metal in pounds per square inch.

Example.—The diameter of a wrought iron flue is 6 inches, and the pressure to which it is to be submitted is 425 lbs. per square inch, what should be the thickness of the metal?

Assume the tensile strength to be as above, 29,651 *lbs.*

$$\frac{425 \times 6}{29651 \times 2} = \frac{2550}{59302} = \cdot 043 \textit{ in.}$$

The tenacity or tensile resistance of wrought iron boiler plates, ranges from 62,000 to 42,000 lbs.* per square inch; hence it appears,

* Including English plates.

that in the cases given, are duction of tenacity of about ·4 must be made.

From Experiments 7, 8, 10, and 11, and 31, 32, 33, and 34, it appears that tubes or flues subjected to internal pressure or bursting, have much greater resistance than when subjected to external pressure or collapsing; in the cases given where the lengths of the collapsed tubes were 2·5 feet, the difference is about 6·2 times.

The difference, however, between these strains cannot be determined as a rule, for the reason that the resistance to internal pressure is inversely as the diameter of the tube or flue alone, without regard to its length; whereas, with the resistance to collapse, the stress is inversely as the product of the diameter and the length.

Application to Construction of the Results of the Experiments.

Throughout the experiments here enumerated, it has been proved that the resistance to collapse from a uniform external pressure, in cylindrical tubes or flues, varies in the inverse ratio of the lengths. This law has been tested to lengths not exceeding fifteen diameters of the tube or flue; but the point at which it ceases to hold true is as yet undetermined, and it can only be ascertained by a series of experiments on tubes and flues of greater length, in which the strength of the material modifies the above law of resistance to collapse. Such experiments are desirable, but the results already obtained appear to supply the data necessary for calculating the resistance, and proportioning the material in ordinary cases.

Thus, with drawn or brazed tubes, when there are no courses and consequent laps; their length is an essential element in an estimate of their resistance to collapse; but with riveted flues, constructed in courses, the objection to length is removed, as the addition of the laps is a source of great resistance to collapse, rendering the flue alike to a series of lengths, each equal to the distance between the centres of the courses.

In a boiler of the ordinary construction, of 30 feet in length and 3 feet 6 inches in diameter, with two flues 16 inches in diameter, the cylindrical external shell has 2·8 times resistance to the force tending to burst it, than the flues have to resist the same force to collapse them. This being the case, it is not surprising that the collapse of the internal flues so frequently occurs. To remedy this, and to place the security of boilers upon a more certain basis, it is essential that every part should be of *uniform strength* to resist the stress upon it. The equalization of the powers of resistance is the more important, as the increased strength of the outer shell is absolutely of no value, so long as the internal flues remain liable to be destroyed by collapse, at a pressure of only one-third of that required to burst the envelope which contains them.

The following Table, deduced from experiments, exhibits the collapsing pressure of flues, and bursting pressure of boilers of different diameters and thickness of metal:—

Table *of the Resistance of Wrought Iron Flues to an External or Collapsing Pressure, and of the Shells of Boilers to an Internal or Bursting Pressure.*

Tensile resistance of the Plates without riveting is taken at a mean of 55,000 *pounds per square inch.*

FLUES.				SHELLS.			
Diameter of Flue.	Length of Flue.	Thickness of Flue.	Collapsing Pressure per square inch.	Diameter of Shell.	Thickness of Shell.	Bursting Pressure per square inch.	
						Single riveted.	Double riveted.
Ins.	Feet.	Ins.	lbs.	Feet.	Ins.	lbs.	lbs.
6	10	·2	417	2	·25	573	745
6·5	"	·2	385	2·6	·25	458	596
7	"	·2	357	3	·25	382	496
	"	·25	580	3·4	·25	318	414
7·5	"	·2	333		·3125	398	518
	"	·25	542	3·6	·25	327	426
8	"	·2	312		·3125	409	532
	"	·25	508	4	·25	286	372
8·5	"	·2	294		·3125	353	465
	"	·25	478	4·6	·25	254	331
9	"	·2	278		·3125	318	413
	"	·25	451	5	·25	229	298
9·5	"	·2	263		·3125	286	372
	"	·25	427	5·6	·25	208	270
10	12	·2	227		·3125	260	338
	"	·25	354		·375	312	406
	"	·3125	612	6	·25	191	248
10·5	"	·2	216		·3125	239	311
	"	·25	337		·375	286	372
	"	·3125	583	6·6	·3125	220	287
11	"	·2	206		·375	264	344
	"	·25	322	7	·3125	204	266
	"	·3125	557		·375	245	319
11·5	"	·2	197	7·6	·3125	191	248
	"	·25	308		·375	229	298
	"	·3125	532	8	·3125	179	233
12	15	·2	153		·375	215	279
	"	·25	239	8·6	·3125	168	219
	"	·3125	415		·375	202	263
12·5	"	·25	229	9	·3125	159	207
	"	·3125	398		·375	191	248
13	"	·25	220	9·6	·3125	150	196
	"	·3125	384		·375	181	235
13·5	"	·25	212	10	·3125	143	186
	"	·3125	369		·375	172	224
14	18	·25	176		·5	229	298
	"	·3125	305	10·6	·3125	136	177
14·5	"	·25	169		·375	163	212
	"	·3125	294		·5	218	284
15	20	·25	157	11	·375	156	203
	"	·3125	276		.5	208	271
15·5	"	·25	152	11·6	·375	149	194
	"	·3125	267		·5	199	259
16	"	·25	148	12	·375	143	186
	"	·3125	231		·5	191	248

NOTE.—The single riveted are estimated at ·5 the resistance of the plates, and the double riveted at ·65; this reduction from ·56 and ·7, as determined by Fairbairn, is to meet defects of rivets, cracks of plates from the priming of rivet holes, &c., his experiments having been made with rivets and plates in a normal condition.

APPLICATION OF THE PRECEDING TABLE.

To ascertain the Ultimate Collapsing Resistance of a Flue.

When the thickness of the metal is not given in the above Table.

RULE.—Take the square of the thickness of the metal, if given in decimals of an inch, or that due to the number of it, if given by a wire gauge, and multiply it by its proportional unit or multiplier from the table preceding (page 395), the thickness and length being duly considered, and divide the product by the product of the diameter of the flue in inches, and the length of it in feet.

EXAMPLE.—The diameter of a flue is 15 ins., the thickness of the metal No. 3 U. S. wire gauge (= ·23 in.), and the length of it is 30 feet; what is its ultimate resistance to collapse per square inch?

Multipliers for thicknesses from ·125 to ·25 in., and for a length of 30 feet, are 810,000 to 920,000, the difference of which is (920,000 — 810,000) = 110,000, and the difference in thickness (·25 — ·125) = ·125

Then, as ·125 : 110,000 : : ·105 (·23 — ·125) : 92,400.

Difference in length (35 — 25) = 10.

Then, as 10 : 110,000 : : 5 (35 — 30) : 55,000.

Consequently, $\frac{92{,}400 + 55{,}000}{2} = 73{,}700$, a mean multiplier of thicknesses and length, which added to 810,000, the multiplier for ·125 in. in thickness and 25 feet in length, = 883,700.

Hence, $\frac{\cdot 23^2}{30 \times 15} \times 883{,}700 = \frac{\cdot 0529}{450} \times 883{,}700 = 103{\cdot}88$ *lbs.*

To ascertain the Ultimate Bursting Resistance of the Shell of a Boiler.

When the thickness of the metal is not given in the above table.

RULE.—Double the thickness given, or as ascertained, for a wire gauge, and multiply the sum by the tensile resistance of the metal, and divide the product by the diameter of the flue in inches.

EXAMPLE.—The diameter of the shell of a wrought iron boiler, single riveted, is 5 feet, and the thickness of the metal is ·28 in.; what is the ultimate resistance to a bursting pressure?

$$\cdot 28 + \cdot 28 \times 55{,}000 = 30{,}800,$$

and $\frac{30{,}800}{60} = 513{\cdot}33$ *lbs.*, which × ·5 for reduction of resistance of the plates for single riveting = 256·67 *lbs.*

NOTE.—From the results given in the table and deduced from the

rules, such allowances for the resistance and wear of the plates, oxidation, &c., &c., are to be made, as the character of the metal, the nature of the service, and the circumstance of using fresh or salt water, &c., &c., will render necessary.

In plates single riveted, it is customary in practice to estimate the tensile resistance of the metal at one-fifth of its ultimate resistance, and, when they are double riveted, at one-fourth of it.

Comparison between the Resistance to External and Internal Pressure in Wrought Iron Single Riveted Flues of different Diameters and Lengths.

Diameter.	Thickness.	Length.	External pressure per sq. inch.	Internal pressure per sq. inch.	Ratio.
Ins.	Ins.	Feet.	lbs.	lbs.	
6	·15	10	205	1375	1 to 6·7
12	·2	15	163	917	1 " 5·6
18	·25	20	135	764	1 " 5·6

RESISTANCE OF LEAD TUBES TO INTERNAL PRESSURE.

Diameter.	Length.	Thickness.	Pressure of rupture per sq. inch.	REMARKS.
Ins.	Ins.	Ins.	lbs.	
3	$14\frac{1}{2}$	·25	374	Ruptured in body of tube.
3	31	·25	364	

Assuming 370 as the mean of the pressure of rupture in lbs. per square inch,

$$\text{P} = \frac{\text{P}' \times \text{D}}{2\,t}, \quad \text{or} \quad \frac{370 \times 3}{2 \times \cdot 25} = 2220\ lbs.,$$

$$\text{and} \quad \frac{2\,t \times \text{P}}{\text{P}'} = d, \quad \text{or} \quad \frac{2 \times \cdot 25 \times 2220}{370} = 3\ ins.,$$

$$\text{and} \quad \frac{\text{P} \times 2\,t}{d} = \text{P}'.$$

Hence, *To ascertain the Thickness of a Lead Pipe, the Diameter and the Pressure in pounds per square inch being given.*

RULE.—Multiply the pressure in pounds per square inch by the diameter of the pipe in inches, and divide the product by twice the tensile resistance of the metal in pounds per square inch.

EXAMPLE.—The diameter of a lead pipe is 3 inches, and the pressure to which it is to be submitted is 370 lbs. per square inch; what should be the thickness of the metal?

$$\frac{370 \times 3}{2220 \times 2} = \frac{1110}{4440} = \cdot 25\ in.$$

RESISTANCE OF GLASS GLOBES AND CYLINDERS TO COLLAPSING (Fairbairn).

Globes.				Cylinders.			
Diameter.	Length.	Thickness.	Collapsing pressure per sq. inch.	Diameters.		Thickness.	Collapsing pressure per sq. inch.
Ins.	Ins.	Ins.	lbs.	Ins.	Ins.	Ins.	lbs.
5·05	4·76	·015	292	4·06	13·75	·045	180
5·08	4·70	·019	410	4·02	14	·065	297
4·95	4·72	·021	470	4·05	7	·046	380
5·60		·020	475	4·05	7	·034	202
8·22	7·45	·010	350	3 09	14	·024	850
8·20	7·30	·012	420	3·08	14	·032	103
8·20	7·40	·015	600	3·25	14	·042	175

From which it appears that the resistance of cylindrical vessels exposed to a uniform external pressure, varies inversely as their lengths.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By WM. BRYSON, Civ. Eng.

(Continued from page 330.)

Mr. Hodgkinson gives the following formula for the strength of a solid pillar of cast iron:

$$W = m \times \frac{D^{3.5}}{L^{1.63}},$$

m representing a weight which varied from 49·94 tons in the strongest iron tried, to 33·60 tons in the weakest.

Mr. H. also gives the following formulæ for the strength of a hollow pillar of Low Moor iron, No. 2:

$$W = 46{\cdot}65 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$$

$$W = 42{\cdot}347 \frac{D^{3.5} - d^{3.5}}{L^{1.63}}.$$

"It was found that when the length was the same, the strength varied as the 3·5 power of the diameter, and when the diameter was the same and the length varied, the strength was inversely as the 1·63 power of the length; both of these were obtained from mean results of many experiments."

NOTE.—The above formulæ are deduced from experiments on pillars 10 feet long, and from 2½ inches to 4 inches diameter.

It was shown at p. 186 of this *Journal*, and by the several tables, that similar formulæ were applicable for solid pillars when the length exceeded 25 diameters, and for hollow pillars when the length varied from about 28 to 34 diameters, the variability depending a good deal upon the sectional thickness.

In the following formulæ by which the tables for cast iron pillars are calculated, the co-efficients for the strength which are not Mr. Hodgkinson's, are all deduced from his experiments. The 41·77 is a mean of the strongest and weakest iron tried, and the 33·60 is the weakest.

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Name of Iron.	Length or height of Pillar in feet.	Diameter in inches.	Calculated breaking weight in tons from formula, $W = 57{\cdot}17 \frac{D^{3.55}}{L^{1.7}}$.	Calculated breaking weight in tons from formula, $W = 50{\cdot}94 \frac{D^{3.5}}{L^{1.63}}$.	Breaking weight in tons from Mr. Hodgkinson's experiments.
Old Park Iron, Stourbridge,	8	$2\frac{1}{2}$	43·11	42·44	
	10	"	29·50	29 50	29·50
	12	"	21·63	21·91	
Derwent Iron, Durham,			$W = 54{\cdot}32 \frac{D^{3\ 55}}{L^{1.7}}$.	$W = 48{\cdot}40 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	40·96	40·32	
	10	"	28·02	28·03	28·03
	12	"	20·56	20·82	
Portland Iron, Tovine, Scotland,			$W = 52{\cdot}90 \frac{D^{3.55}}{L^{1.7}}$.	$W = 47{\cdot}14 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	39·89	39·27	
	10	"	27·29	27·30	27·30
	12	"	20 02	20·28	
Calder Iron, Lanarkshire,			$W = 52{\cdot}49 \frac{D^{3.55}}{L^{1.7}}$.	$W = 46{\cdot}77 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	39·58	38·96	
	10	"	27·08	27·08	27·09
	12	"	19·86	20·12	
Level Iron, Staffordshire,			$W = 47{\cdot}80 \frac{D^{3.55}}{L^{1.7}}$.	$W = 42{\cdot}59 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	36·04	35·48	
	10	"	24 66	24·66	24 67
	12	"	18·09	18 32	
Coltness Iron, Edinburgh, and Carron Iron, Stirlingshire,			$W = 45{\cdot}58 \frac{D^{3.55}}{L^{1.7}}$.	$W = 40{\cdot}61 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	34·34	33 83	
	10	"	23·52	23·51	23 52
	12	"	17·25	17·47	
Blaenavon Iron, South Wales,			$W = 42{\cdot}73 \frac{D^{3.55}}{L^{1.7}}$.	$W = 38{\cdot}07 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	32·22	31·71	
	10	"	22·05	22·04	22·05
	12	"	16·17	16·37	
Old Hill Iron, Staffordshire,			$W = 38{\cdot}85 \frac{D^{3.55}}{L^{1.7}}$.	$W = 34{\cdot}62 \frac{D^{3.5}}{L^{1.63}}$.	
	8	$2\frac{1}{2}$	29·29	28·84	
	10	"	20·04	20·04	20·05
	12	"	14·70	14·89	

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Diameter in inches.	Calculated breaking weight in tons from formula, $W = 42·20 \frac{D^{3·6}}{L^{1·7}}$.	Calculated breaking weight in tons from formula, $W = 41·77 \frac{D^{3·5}}{L^{1·63}}$.	Calculated breaking weight in tons from formula, $W = 33·60 \frac{D^{3·5}}{L^{1·63}}$.
8	2	14·91	15·93	12·81
9	"	12 21	13·14	10·57
10	"	10·20	11·07	8·90
11	"	8·68	9·48	7·62
12	"	7·48	8·22	6 61
8	2½	33·31	34·80	30 80
9	"	27·26	28·72	23·11
10	"	22·79	24·19	19·45
11	"	19·38	20·71	16·66
12	"	16·72	17·97	14·45
8	3	64·22	65·88	53·00
9	"	52·56	54·37	43·73
10	"	43·94	45·79	36 83
11	"	37·37	39·21	31·54
12	"	32·23	34·02	27·36
13	"	28·13	29·86	24·02
14	"	24 80	26 46	21·28
15	"	22·05	23·64	19 02
10	4	123·79	125·32	100·81
11	"	105·28	107·31	86·32
12	"	90·80	93·11	74·90
13	"	79 25	81·72	65·74
14	"	69·87	72·42	58·26
15	"	62·13	64·72	52·06
16	"	55·68	58 26	46·86
17	"	50·22	52·75	42·43
18	"	45·57	48·08	38·67
19	"	41·57	44 03	35 42
20	"	38·10	40·49	32·57

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 42·347 \frac{D^{3·5} - d^{3·5}}{L^{1·63}}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{W c}{W + \frac{3}{4} c}$.	Breaking weight in tons if irregularly fixed.
8	24	4	2	235·87		166·86	461·58	150·12	50·04
9	27	"	"	265·35		137·53	"	131·23	43·74
10	30	"	"	294·84		115·83	"	115·72	38·57
11	33	"	"	324·28	99·18				33·06
12	36	"	"	353·76	86·05				28·68
13	39	"	"	383·24	75·53				25 17
14	42	"	"	412·72	66·93				22 31

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed (Continued).

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 42{\cdot}347 \frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{Wc}{W + \frac{3}{4}c}$.	Breaking weight in tons if irregularly fixed.
15	45	4	2	442·20	59·81				19·93
16	48	"	"	471·68	53·84				17·94
17	51	"	"	501·16	48 75				16·25
18	54	"	"	530·64	44·44				14·81
19	57	"	"	560·12	40·69				13·56
20	60	"	"	589·60	37·42				12·47
8	19·2	5	3	314·49		332·15	615·75	257·59	85·86
9	21·6	"	"	353·80		274·29	"	229 44	76·48
10	24	"	"	393·12		231·02	"	205·31	68·43
11	26·4	"	"	432·43		197·82	"	184·66	61·55
12	28·8	"	"	471·74		171·63	"	166·83	55·61
13	31·2	"	"	511·05	150·64				50·21
14	33·6	"	"	550·36	133·50				44·50
15	36	"	"	589·68	119·30				39·76
16	38·4	"	"	628·99	107·39				35·79
17	40·8	"	"	668 30	97·24				32·41
18	43·2	"	"	707·61	88·63				29·54
19	45·6	"	"	746·92	81·16				27·05
20	48	"	"	786·24	74·64				24 88
					$W = 46{\cdot}65 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$.				
8	17·454	5½	3¾	317·84		429·54	622·54	298·29	
9	19·636	"	"	357·57		351·60	"	267·42	
10	21·818	"	"	397·30		293 94	"	240·50	
11	23 100	"	"	437 03		249 97	"	217·07	
12	26·181	"	"	476·76		215·60	"	196·65	
13	28·363	"	"	516·49		188·17	"	178·80	
14	30·545	"	"	556·22		165·89	"	163·20	
15	32·727	"	"	595·95	147·54				
16	34·909	"	"	635·68	132·20				
17	37·090	"	"	675·41	119·25				
18	39·272	"	"	715·14	108·22				
19	41·454	"	"	754·87	98·71				
20	43·636	"	"	714·60	90·46				

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 42{\cdot}20 \frac{D^{3\cdot6}}{L^{1\cdot7}}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{Wc}{W + \frac{3}{4}c}$.
8	17·454	5½	594·56		569·33	1164·14	459·48
9	19·636	"	668·88		466·02	"	405·12
10	21·818	"	743·20		389·60	"	359·18

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed (Continued).

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 42{\cdot}20 \frac{D^{3\cdot6}}{L^{1\cdot7}}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{W c}{W + \frac{3}{4} c}$.
11	23·100	5½	817·52		331·32	1164·14	320·23
12	26·181	"	891·84	285·76			
13	28·363	"	966·16	249·41			
14	30·545	"	1040·48	219 88			
15	32·727	"	1114·80	195·55			
16	34·909	"	1189·12	175 23			
17	37·090	"	1263·44	158·06			
18	39·272	"	1337·76	143·43			
19	41·454	"	1412·08	130·83			
20	43·636	"	1486·40	119·91			

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 42{\cdot}347 \frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{W c}{W + \frac{3}{4} c}$.
8	16	6	4	393·12		572·83	769·69	383·36
9	18	"	"	442·26		472·71	"	346·52
10	20	"	"	491·40		398·15	"	314·17
11	22	"	"	540·54		340·91	"	285·78
12	24	"	"	589·68		295·79	"	260·77
13	26	"	"	638·82		259·62	"	238·77
14	28	"	"	687·96		230·08	"	219·35
15	30	"	"	737·10		205·59	"	202·13
16	32	"	"	786·24	185·07			
17	34	"	"	835·38	167·58			
18	36	"	"	884·52	152 75			
19	38	"	"	933·66	139 88			
20	40	"	"	982·80	128 64			
21	42	"	"	1031·94	118 80			
22	44	"	"	1081·08	110 13			
23	46	"	"	1130 22	102·43			
24	48	"	"	1179 36	95·56			
25	50	"	"	1228·50	89·41			
26	52	"	"	1277·64	83 87			
27	54	"	"	1326·78	78 87			
28	56	"	"	1375·92	74·33			
29	58	"	"	1425·06	70·20			
30	60	"	"	1474·20	66·42			

Solid Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Side of the square in inches.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formula, $W = 10{\cdot}95 \frac{D^4}{L^2}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{W c}{W + \frac{3}{4} c}$.
8	16	6	2·00	94·32		221·73	124·20	87·45
9	18	"	2·25	106·11		175·20	"	81·08
10	20	"	2·50	117·90		141·91	"	74 98
11	22	"	2·75	129·60		117·28	"	69·22
12	24	"	3·00	141·48		98·55	"	63·84
13	26	"	3·25	153 27		83·97	"	58·88
14	28	"	3·50	165·06		72·40	"	54 31
15	30	"	3·75	176·85		63·07	"	50·14
16	32	"	4·00	188 64		55·43	"	46·33
17	34	"	4·25	200·43		49 10	"	42·86
18	36	"	4·50	212·22		43·80	"	39·72
19	38	"	4·75	224 01		39·31	"	36·85
20	40	"	5·00	235·80		35·47	"	34·25
21	42	"	5·25	247·59		32·17	"	31·88
22	44	"	5·50	259·38	29·32			
23	46	"	5·75	271·17	26·82			
24	48	"	6 00	282·96	24·63			
25	50	"	6·25	294·75	22·70			
26	52	"	6·50	306·54	20·99			
27	54	"	6·75	318 33	19 46			
28	56	"	7·00	330·12	18·10			
29	58	"	7·25	341·91	16·87			
30	60	"	7·50	353·70	15·76			

Solid Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 7{\cdot}81 \frac{D^4}{L^2}$.			
8	16	6	2 00	87·04		158·15	105·84	70 46
9	18	"	2·25	97·92		124 96	"	64·72
10	20	"	2·50	108 80		101·21	"	59 31
11	22	"	2 75	119·68		83·65	"	54·30
12	24	"	3·00	130·56		70·29	"	49·70
13	26	"	3 25	141·44		59·89	"	45·51
14	28	"	3·50	152·32		51·64	"	41·71
15	30	"	3 75	163·20		44·98	"	38·28
16	32	"	4·00	174·08		39·53	"	35·18
17	34	"	4·25	184·96		35 02	"	32 39
18	36	"	4 50	195·84		31·24	"	29·89
19	38	"	4·75	206·72		28·03	"	27·62
20	40	"	5 00	217·60	25·30			
21	42	"	5·25	228·48	22 95			
22	44	"	5·50	239·36	20 91			
23	46	"	5·75	250·24	19·13			
24	48	"	6·00	261·12	17·57			
25	50	"	6·25	272·00	16·19			
26	52	"	6·50	282·88	14·97			
27	54	"	6·75	293·76	13·88			
28	56	"	7·00	304·64	12·91			
29	58	"	7·25	315·52	12·03			
30	60	"	7·50	326·40	11 24			

Solid Cylindrical Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formula, $W = 6{\cdot}71 \frac{D^4}{L^2}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{Wc}{W + \frac{3}{4}c}$.
8	16	6	1·570	74·08		135·87	97·54	63·40
9	18	"	1·766	83·34		107·36	"	58 01
10	20	"	1·963	92·60		86·96	"	52 97
11	22	"	2·159	101·86		71·86	"	48·33
12	24	"	2·355	111·12		60·39	"	44·10
13	26	"	2·551	120·38		51·45	"	40·27
14	28	"	2·748	129 64		44·36	"	36·82
15	30	"	2 944	138·90		38·64	"	33·71
16	32	"	3·140	148·16		33·96	"	30 92
17	34	"	3·337	157·42		30·09	"	28·42
18	36	"	3·533	166·68		26·84	"	26·18
19	38	"	3·729	175·94	24·08			
20	40	"	3·926	185 20	21·74			
21	42	"	4·122	194·46	19·71			
22	44	"	4·318	203·72	17·96			
23	46	"	4·514	212·98	16·43			
24	48	"	4 711	222·24	15·09			
25	50	"	4·907	231·50	13·91			
26	52	"	5 103	240·76	12·86			
27	54	"	5·300	250·02	11·92			
28	56	"	5·496	259·28	11·09			
29	58	"	5·692	268·54	10·34			
30	60	"	5·889	277·80	9·66			

Solid Cylindrical Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 4{\cdot}79 \frac{D^4}{L^2}$.			
8	16	6	1·570	68·40		96·99	83·12	50·59
9	18	"	1·766	76·95		76·64	"	45·83
10	20	"	1·963	85·50		62·07	"	41·46
11	22	"	2·159	94·05		51·30	"	37·52
12	24	"	2·355	102·60		43·11	"	33·98
13	26	"	2·551	111·15		36·73	"	30 81
14	28	"	2·748	119·70		31·67	"	28·00
15	30	"	2·944	128·25		27·59	"	25·50
16	32	"	3·140	136·80		24·24	"	23·27
17	34	"	3·337	145·35		21·48	"	21·30
18	36	"	3·533	153·90	19·16			
19	38	"	3·729	162·45	17·19			
20	40	"	3·926	171·00	15·51			
21	42	"	4·122	179·55	14·07			
22	44	"	4·318	188·10	12·82			
23	46	"	4·514	196·65	11·73			
24	48	"	4·711	205·20	10·77			
25	50	"	4·907	213·75	9·93			
26	52	"	5·103	222·30	9 18			
27	54	"	5·300	230·85	8·51			
28	56	"	5·496	239·40	7·91			
29	58	"	5·692	247·95	7·38			
30	60	"	5·889	256·50	6·89			

Solid Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Side of the square in inches.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formula, $W = 10{\cdot}95 \frac{D^4}{L^2}$.	Value of W.	Value of c.	Calculated breaking weight in tons from formula, $Y = \frac{Wc}{W + \frac{3}{4}c}$.	Breaking weight in tons if irregularly fixed.
8	13 5-7	7	2·72	128·40		410·79	169·05	129·18	43·06
9	15 3-7	"	3 06	144·45		324·57	"	121·56	40·52
10	17 1-7	"	3·40	160·50		262 90	"	114·05	38·01
11	18 6-7	"	3·74	176 55		217·28	"	106·75	35·58
12	20 4-7	"	4·08	192·60		182·57	"	99·76	33·25
13	22 2-7	"	4·42	208·65		155·56	"	93·14	31·04
14	24	"	4·76	224·70		134·13	"	86 90	28·96
15	25 5-7	"	5·10	240·75		116·84	"	81·07	27·02
16	27 3-7	"	5·44	256·80		102·69	"	75·65	25·21
17	29 1-7	"	5·78	272·85		90·97	"	70·62	23·54
18	30 6-7	"	6·12	288·90		81·14	"	65·97	21·99
19	32 4-7	"	6·46	304·95		72·82	"	61·67	20·55
20	34 2-7	"	6·80	321·00		65·72	"	57·71	19·23
21	36	"	7·14	337·05		59·61	"	54·06	18·02
22	37 6-7	"	7·48	353·10		54·32	"	50·70	16·90
23	39 3-7	"	7·82	369·15		49·69	"	47·60	15·86
24	41 1-7	"	8·16	385·20		45·64	"	44·74	14·91
25	42 6-7	"	8·50	401·25	42·06				14·02
26	44 4-7	"	8 84	417·30	38·89				12·96
27	46 2-7	"	9·18	433·35	36·06				12 02
28	48	"	9·52	449 40	33·53				11·17
29	49 5-7	"	9·86	465·45	31·26				10·42
30	51 3-7	"	10·20	481·50	29·21				9·73

Solid Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 7{\cdot}81 \frac{D^4}{L^2}$.				
8	13 5-7	7	2·72	118·48		292·99	144·06	105·24	35·08
9	15 3-7	"	3·06	133·29		231·50	"	98·22	32·74
10	17 1-7	"	3·40	148·10		187·51	"	91·39	30·46
11	18 6-7	"	3·74	162 91		154 97	"	84·88	28·29
12	20 4-7	"	4·08	177·72		130·22	"	78·73	26·24
13	22 2-7	"	4·42	192·53		110·95	"	72·98	24·32
14	24	"	4·76	207·34		95·67	"	67·65	22·55
15	25 5-7	"	5·10	222·15		83·34	"	62·73	20·91
16	27 3-7	"	5·44	236·96		73·24	"	58·20	19·40
17	29 1-7	"	5·78	251·77		64·88	"	54·05	18·01
18	30 6-7	"	6·12	266·58		57·87	"	50·24	16·74
19	32 4-7	"	6·46	281·39		51·94	"	46·77	15·59
20	34 2-7	"	6·80	296·20		46·87	"	43·58	14·52
21	36	"	7·14	311·01		42·52	"	40·68	13·56
22	37 6-7	"	7·48	325·82		38·74	"	38·02	12·67
23	39 3-7	"	7·82	340·63	35·44				11·81
24	41 1-7	"	8 16	355·44	32·55				10·85
25	42 6-7	"	8·50	370·25	30·00				10·00
26	44 4-7	"	8 84	385·06	27·73				9·24
27	46 2-7	"	9·18	399·87	25·72				8·57
28	48	"	9·52	414·68	23·91				7·97
29	49 5-7	"	9·86	429·49	22·35				7·45
30	51 3-7	"	10·20	444·30	20·83				6·94

(To be Continued.)

Fastening of Iron Bars into Stone.

For this purpose, lead is almost always employed, which forms a voltaic couple with the iron, by which that metal is rapidly rusted. Zinc, on the contrary, would preserve the iron.—*Dingler's Polytech. Jour. Bull. Soc. d'Encour. pour l'Indus. Nationale.*

Artesian Well at Passy.

At length the artesian well at Passy (Paris) which has cost so much labor, expense, and anxiety, has met with a successful issue. At a depth of 587 metres (1925·77 ft.), the stratum of water was reached which rises 230 ft. above the level of the Seine, at a temperature of 82·5° Fahr. The water is very pure, and carries with it much less sand than that of Grenelle. The quantity discharged is 25,000 cubic metres (32,695 cub. yds.) in 24 hours.—*Cosmos.*

The Working Power of Coal.

From the Lond. Mechanics' Mag., September, 1861.

Professor Rogers estimates that nearly one-sixth of the total annual produce of our coal mines is used for the production of mechanical power alone, from which a power equal to that of 66,000,000 able bodied men is obtained. Each acre of a seam yielding three feet of pure fuel, is equal to about 5000 tons, and possesses a reserve of mechanical strength equal to the labor of 1600 men during their whole life; and each square mile of the same bed contains 8,000,000 tons of fuel, which is equal to 1,000,000 men laboring through twenty years of their ripe strength. Upon the same calculation, the total annual coal production of the United Kingdom (65,000,000 tons) is equal to the strength of 400,000,000 strong men, or more than double the number of adult males now upon the globe.

For the Journal of the Franklin Institute.

On Feed Pump Resistance. By Wm. H. Shock, Ch. Eng. U. S. N.

In the January number of this *Journal* for the present year, will be found a series of diagrams taken from the feed pumps of the U.S. steam frigate *Powhatan* (paddle wheel), with the data and results deduced therefrom.

Since that time, I have been kindly furnished by Chief Engineer Thos. A. Shock, of the U. S. steam sloop *Mohican* (screw), with a series of diagrams taken from the cylinders and feed pumps of that ship, which enables me to continue the investigation of "Feed Pump Resistance."

The steam sloop *Mohican* is one of six sloops built in 1858–9, and since her completion has been actively engaged on the coast of Africa.

Her general dimensions are as follows:—

Length, extreme, . . .	232 feet.
" at load line, . . .	188 " 6 ins.
Breadth of beam, . . .	33 "
Tonnage, . .	1330.

She is supplied with two horizontal direct-acting double piston rod engines, of the following dimensions:—

Diameter of cylinders, . . .	54 inches.
Stroke of piston, . . .	30 "
Diameter of fresh-water air-pump, . .	15 "
" salt " " . .	21 "
" feed pump, . . .	4 "
Internal diameter of feed pipes, . .	3½ "

One screw, composition, with an increasing pitch.

Diameter, ...	12 ft. 6 ins.
Length, . . .	2 " 9 "
Pitch, . . .	from 17 to 21 "

Diagrams A and B, and Nos. 1, 2, and 3, were taken as near the same period of time as was practicable, to avoid as far as possible any error that might arise from a change in the working condition of the engines. The data, therefore, as to revolutions, &c., &c., affixed to diagrams A and B is critically correct for Nos. 1, 2, and 3. As our object is to ascertain what per centum of the developed H. P. of the engines was absorbed in overcoming the resistance of feed pumps, it becomes necessary as a preliminary step to ascertain what this power was, and for this purpose we have recourse to diagrams A and B, from which we find the following:—

Mean effective pressure from card A = 6·9 lbs.
" " " B = 8·3 "

and $\frac{6{\cdot}9 + 8{\cdot}3}{2} = 7{\cdot}6$ lbs., as the mean average effective pressure acting on the pistons.

$$\text{Therefore,} \qquad \frac{2290 \times 7{\cdot}6 \times 42{\cdot}4 \times 10}{33{,}000} = 223{\cdot}6 + \text{H. P.,}^*$$

the total effect developed by the engines, when the accompanying series of diagrams were taken.

Having ascertained that the exponent of labor performed by the engines is represented by 223·6 + H. P., it remains to be seen what proportion of it was absorbed by the pumps.

The area of the steam piston, as we have seen, is 2290·2 sq. ins.
Area of pump plunger, . . 12·556 "

and $\left(\frac{12{\cdot}556}{2290{\cdot}2}\right){\cdot}5 = {\cdot}0027434 =$ the proportion of area of feed pump to double that of the steam cylinder.

From diagrams Nos. 1, 2, and 3, we ascertain the resistance per square inch of pistons under the three several conditions in which they were taken, as follows:—

* About one-half the usual working power of the engines.

CARD No. 1.—The mean pressure . . = 6·07 lbs.
and $6{\cdot}07 \times {\cdot}0027434 = {\cdot}016652438$
= the resistance per sq. in. of pistons; or, in terms of H. P., we have

$$\frac{12{\cdot}566 \times 6{\cdot}07 \times 42{\cdot}4 \times 2{\cdot}5}{33{,}000} = {\cdot}245 \text{ H. P.}$$

CARD No. 2.—The mean pressure . . = 3·8 lbs.
and $3{\cdot}8 \times {\cdot}0027434 = {\cdot}01042492$
= the resistance per sq. in. of pistons; or, in terms of H. P., we have

$$\frac{12{\cdot}566 \times 3{\cdot}8 \times 42{\cdot}4 \times 2{\cdot}5}{33{,}000} = {\cdot}153 \text{ H. P.}$$

CARD No. 3.—The mean pressure . . = 5·5 lbs.
and $5{\cdot}5 \times {\cdot}0027434 = {\cdot}0150887$
= the resistance per sq. in. of pistons; or, as in the other two cases, we have

$$\frac{12{\cdot}566 \times 5{\cdot}5 \times 42{\cdot}4 \times 2{\cdot}5}{33{,}000} = {\cdot}221 \text{ H. P.}$$

By reference to the plate of diagrams, it will be seen that No. 1 represents the power absorbed by *one* pump (in its normal working condition for that speed) to be ·245 H. P., and $\cdot245 \times 2 = \cdot490$ H. P., which represents the total tax on the engines for feed pump resistance "*per se*," as shown by the diagrams, the friction resistance due to packing, &c., not being considered.

It will of course be understood that pump resistance increases with increase of boiler duty, and in addition to the usual tortuous and irregular manner in which feed pipes are generally arranged on board ship (which of itself is a fruitful source of resistance), may be mentioned the confined space in check valve chambers.

In the designs of feed pumps, check valve chambers, &c., particular attention should be given, especially in quick working engines. I know of a case in which a violent jar in the working of feed pumps was removed by the engineer simply enlarging the check valve chambers on boilers half inch, which resulted in the further advantage of not requiring the pump to be so tightly packed as previously, thus avoiding much friction.

—

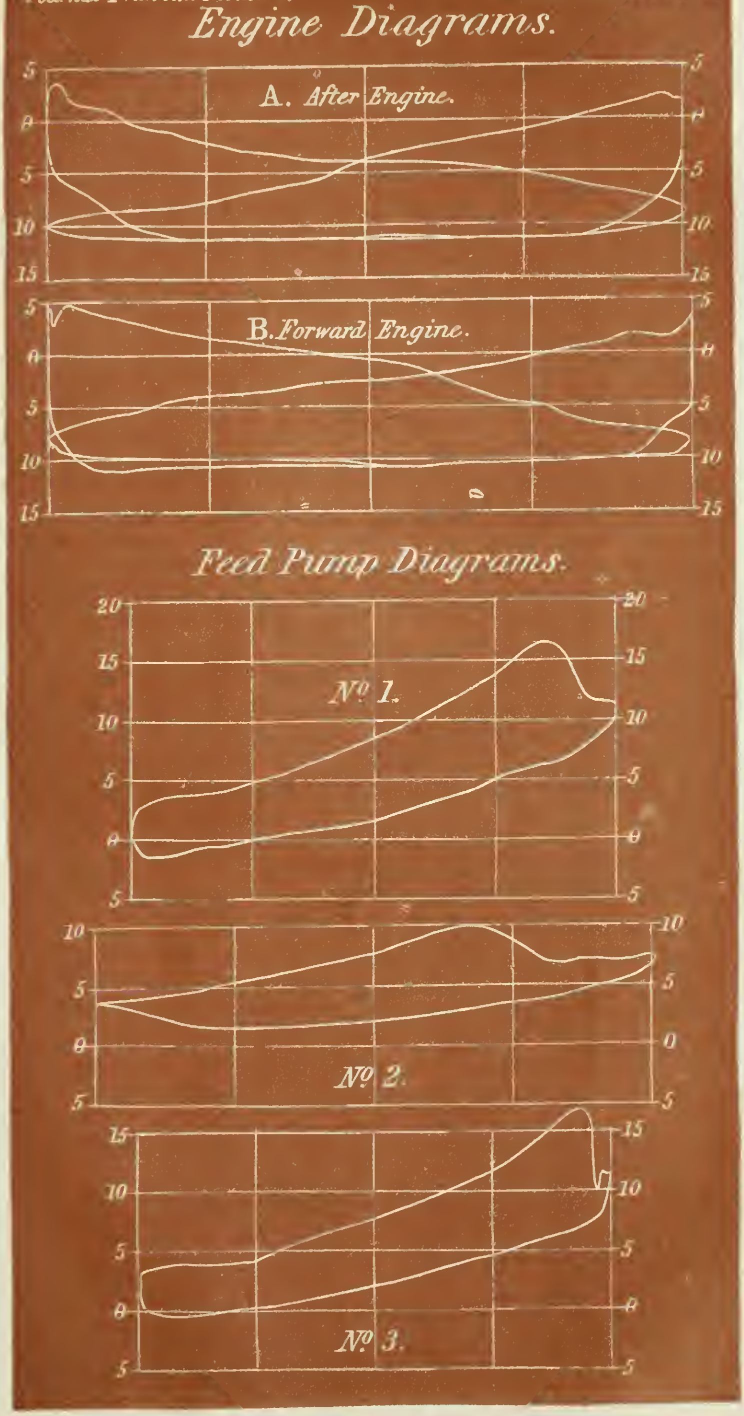
EXPLANATION OF DIAGRAMS.—PLATE II.

ENGINE DIAGRAMS A and B.

Steam, 8½ lbs. Vacuum, 26 inches. Cut-off, 10 inches.
Throttle, 1⅓ holes open. Hot-well, 123°.
Revolutions, 43·4 per minute.

FEED PUMP DIAGRAMS.

No. 1.—Feed pump, valves, &c., in their normal working condition.
No. 2.—Feed pump, safety and supply valves wide open, check valves on boiler closed.
No. 3.—Supply valve on pump, and check valve on boiler, wide open.


Engine Diagrams.
A. After Engine.
B. Forward Engine.
Feed Pump Diagrams.
No 1.
No 2.
No 3.

On the Preparation of Artificial Coloring Matters with the Products Extracted from Coal Tar. By M. E. Kopp.

From the Lond. Chemical News, Nos. 51 and 52.

(Continued from page 339.)

There is a second aniline compound, in which two equivalents of hydrogen are replaced by two equivalents of nitrous acid, dinitraniline$=C_{12}H_5\,2(NO_4)N$. By the prolonged action of sulphuretted hydrogen and ammonia on nitraniline and dinitraniline two new bases are produced,—and *azophenylamine* and *nitrazophenylamine.* The following equations express the reactions which take place:—

$$\underbrace{C_{12}H_6N_2O_4}_{\text{Nitraniline.}}+6HS=\underbrace{C_{12}H_8N_2}_{\text{Azophenylamine.}}+4HO+6S.$$

$$\underbrace{C_{12}H_5N_3O8}_{\text{Dinitraniline.}}+6HS=\underbrace{C_{12}H_7N_3O_4}_{\text{Nitrazophenylamine.}}+4HO+6S.$$

The second of these bases, nitrazophenylamine, merits some attention, inasmuch as it offers some resemblance to the colored derivatives of aniline. It is prepared in the following manner:* Dinitraniline is boiled for two hours with a great excess of sulphide of ammonium. The liquid soon becomes dark red; the yellow crystals of dinitraniline disappear, and are succeeded by a network of delicate needles, of a deep red color, the quantity of which is much increased on cooling the liquid after the reaction has terminated. Oxalic and hydrochloric acids dissolve the nitrazophenylamine, leaving the precipitated sulphur, and also a secondary crystallized product of a dirty green color. The base may be obtained pure by precipitating a boiling oxalic or hydrochloric solution with ammonia and re-crystallizing two or three times from a solution in hot alcohol. In this way nitrazophenylamine is obtained in long slender needles, united in groups, having a clear red color when dry, and showing a golden iridescence. Water, alcohol, and ether easily dissolve it, and the concentrated solutions are of a deep red color. It melts at a high temperature, and the greater part is volatilized apparently without alteration. Heated suddenly, it slightly explodes, leaving a carbonaceous residue.

The salts of nitrazophenylamine are very beautiful compounds, characterized by a dichroism which causes a peculiar iridescence in reflected light. All the salts must be crystallized in the presence of an excess of acid, since both water and alcohol decompose the neutral salts.

Fuchsine prepared by chloride of tin, according to the process of MM. Renard and Franc, appears to be the hydrochlorate of a base, the properties of which greatly resemble those of nitrazophenylamine. The crystallized salts show the same colored reflections, and are decomposed (in part at least) by water and alcohol, the solutions being of a deep red color.

We now proceed to notice the processes for the preparation of coloring matters by means of aniline, and the method of employing them for dyeing fabrics and yarns.

* Gerhardt, *Chimie Organ.*, iii. p. 105; Gmelin's "Handbook," xi. p. 294.

The first on the list is that of Mr. Perkin, for the preparation of aniline, violet, or mauve. A cold solution of sulphate of aniline (rough aniline is used) and a cold solution of bichromate of potash are mixed together and left for ten or twelve hours. An abundant deposit of a black powder is thus obtained, which is separated, well washed with water, and, lastly, dried at 212°. The dried substance is then digested several times with naphtha or commercial benzole, which dissolves a brown tarry or resinous substance, contaminating the coloring matter in the deposit. The residue insoluble in the naphtha is dried again, and then digested with wood spirit or alcohol, or any other liquid able to dissolve the coloring matter. This clear solution is decanted and distilled to recover the solvent. The residue of the distillation is anileine, or aniline violet.

Mr. Perkin gives the following directions for dyeing with anileine: To dye a lilac or purple, an alcoholic solution of the coloring matter is added to a boiling dilute solution of oxalic and tartaric acids, and when the mixture has cooled the materials to be dyed (silk, cotton, &c.) are to be completely immersed in the bath. Mr. Perkin's patent is dated August 26, 1856. In the early part of 1859, M. Verguin, a chemist at Lyons, while experimenting with aniline, discovered a process for converting it into a magnificent purple-red coloring matter. M. Verguin sold his process to MM. Renard and Franc, who patented the process in France on the 8th of April, 1859, and gave the new coloring matter the name of Fuchsine. The process is as follows:— A mixture of ten parts of aniline with six or seven of anhydrous chloride of tin is boiled for fifteen or twenty minutes. The mixture at first turns yellow, then becomes reddish, and ends by assuming a beautiful red color when seen in thin layers; in the mass it appears black. Water is now added, and the whole is heated to ebullition. It is then removed from the fire, allowed to rest a moment for some insoluble matters to deposit, and then filtered while still hot; the residue is exhausted by another boiling with water. The filtered liquor contains the coloring matter in solution. To separate it, advantage is taken of its being insoluble in a saline solution; accordingly, chloride of sodium or a neutral tartrate of potash or soda, in a solid state, is added to the liquor, and as the salt dissolves the coloring matter is deposited. It may then be separated by decantation or filtration.

Fuchsine may be employed for dyeing either in aqueous solution, without a mordant, or with the ordinary saline or acid mordants, always excepting the mineral acids, which alter the color.

A red color is also obtained by acting on aniline with other anhydrous metallic chlorides, bichloride of mercury, perchloride of iron, protochloride of copper, for example. In October, 1859, MM. Renard and Franc added to the above three anhydrous chlorides the hydrate of bichloride of tin, as being equally able to change aniline into fuchsine. A second addition to their patent, in November, 1859, extended the list of colorigenous agents by including the stannous and stannic sulphates, the mercurous and mercuric sulphates, mercurous and mercuric nitrates, nitrate of silver, titanic chloride, mercuric fluoride,

stannic and mercuric bromides, and stannic iodide. A third addition, in the same month, added the ferric and uranic nitrates, uranic chloride, and mercuric chlorate, bromate, and iodate. Sesquichloride of carbon and iodoform were afterwards added in December of the same year. Lastly, a fifth addition was made in February, 1860, the purport of which the author does not exactly know, but which, he believes, includes iodine, arsenic acid, and nitric acid.

We must here quote from a paper by Dr. Hofmann, presented to the Academy of Sciences, on September 20th, 1858,* and entitled, "Contributions to the History of the Organic Bases: IV. Action of Bichloride of Carbon on Aniline":*—

"At the ordinary temperature of the air, aniline and bichloride of carbon do not act on each other. At 100° C. the mixture begins to change; but after digesting for some days, the change is far from being complete. By submitting, however, a mixture of one part of bichloride of carbon and three parts of aniline, the two bodies being in the anhydrous state, to a temperature of 170° or 180° (the boiling point of aniline), for nearly thirty hours, the liquid is changed into a blackish mass, soft and viscous, or hard and brittle, according to the duration of the temperature. This blackish mass is a mixture of several bodies. By exhausting with water a part is dissolved, another part remaining insoluble in a resinous state. With the aqueous solution, potash gives an oily precipitate, which contains a considerable proportion of unchanged aniline. On distilling this oily matter with diluted potash, aniline passes; while a viscous oil, which solidifies by degrees, remains behind. Repeated washings with cold alcohol, and one or two crystallizations from boiling alcohol, render the body perfectly white and pure; a very soluble substance, of a *magnificent crimson color* remaining in solution.

"The blackish portion of the mass, which remains insoluble in water, is easily dissolved by hydrochloric acid; from this solution, it is again precipitated by alkalies, as a dirty-red amorphous powder, soluble in alcohol, and forming a *rich crimson colored solution.* The greater part of this coloring matter is the same as that which accompanies the crystalline fatty body, considerable quantities of this latter substance being sometimes found in the product insoluble in water."

The great resemblance between the experiments of Dr. Hofmann and the process of MM. Renard and Franc is evident. If, as appears from the fourth addition to their patent, fuchsine may be prepared by boiling sesquichloride of carbon with aniline, it is quite clear that Dr. Hofmann had fuchsine in his hand, and that it is identical with the substance which gave a magnificent crimson solution. It is right, however, to add, that if Dr. Hofmann was the first who obtained fuchsine as a secondary product in his theoretical experiments, M. Verguin has certainly the merit of having modified the process, so as to make it capable of industrial application.

* Comptes-Rendus, t. xlvii. p. 492.

In October, 1859, M. Gerber-Keller patented in France the preparation of a red coloring matter, which he called Azaleine, "by means of aniline treated under the influence of heat and in proper proportions with several salts which are formed by the oxyacids of nitrogen, sulphur, chlorine, bromine, and iodine with metallic oxides." We shall complete this too concise and consequently obscure description of the process by adding what is known respecting the preparation. The salts preferred by the author are the mercurous and mercuric nitrates. Aniline is carefully heated to about 150° C., and nitrate of mercury in powder is then dropped in, a small quantity at a time. A higher temperature than 150° must be avoided, or the action becomes too violent, and the coloring matter is destroyed. At every addition of the mercury salt a sort of ebullition is produced, the consequence of the reaction which takes place; metallic mercury is deposited at the bottom of the vessel, and the liquor gradually acquires a deep crimson color. After being decanted, the whole is allowed to cool, and the coloring matter is now washed with a little water and dried. It is then freed from tarry matters by repeated washings with commercial benzine, and finally dissolved in alcohol or wood spirit, the solution being re-precipitated with water, &c., again and again, until the product is sufficiently pure. Absolute purity is not necessary for either dyeing or printing.

Azaleine is soluble in water, but much less so than in alcohol. For dyeing silk and wool, alcoholic solutions are preferred; for printing on cotton, a dilute alcoholic is thickened with gum.

We have recently heard that the process now employed by M. Gerber-Keller is the following: 10 parts of aniline are heated on a water bath to 100°, and 7 parts of mercuric nitrate, dry and in powder, are added by degrees. The mixture is maintained at the temperature of 100° for eight or nine hours, in which time the mass will have become of a magnificent violet-red color. On cooling it forms a thick paste. The greater part of the reduced mercury is found at the bottom of the vessel. To employ the azaleine then produced as a dye or for printing, it is only necessary to treat the pasty mass with boiling water, a mixture of water and alcohol, acetic acid, or any other solvent, and make use of the solution.

The advantage of the last process consists in the moderate heat required, a high temperature seeming to cause the formation of tarry matters.

M. Albert Schlumberger has also described (*Bulletin de la Société Industrielle de Mulhouse*, March, 1860, p. 170) a process for converting aniline into a red coloring matter by means of the neutral nitrate of mercury. He takes 100 parts of anhydrous aniline, and 60 parts of the nitrate of mercury, and heats the mixture to boiling. The mass slowly changes color, at first becoming brown, but in time the whole is transformed into a beautiful red liquid. The operation is finished when the boiling materials are observed to swell up and disengage yellowish vapors. The mass so obtained is washed with two or three times its volume of boiling water, to remove the oils which

are not completely metamorphosed, and then boiled two or three times with water to extract the coloring matter.

In this process, as well as in the preceding, the whole of the mercury is recovered.

In May, 1860, MM. Girard and Delaire obtained a patent for the use of arsenic acid in the preparation of a red coloring matter from aniline. They introduce into a distillatory apparatus 12 parts of dry arsenic acid, and 12 parts of water. When the hydration of the arsenic acid is complete, they add 10 parts of aniline, and shake the whole well together. The mass becomes homogeneous, pasty, and almost solid. A gentle heat is then applied, so as to raise the temperature of the mixture gradually. The mass now becomes liquid. When the operation is properly conducted, only water and a very small quantity of aniline distil. At 120°, a great part of the aniline is changed into the coloring matter, and care must be taken to keep the mixture at this temperature for some time. The heat may then be increased, but it must never pass 160°. The operation lasts four or five hours.

In the above way a perfectly homogeneous mass is obtained, which is fluid above 100°. On cooling, it solidifies, and has the appearance of a hard, brittle substance, with a bronze lustre. It is very soluble in water, to which it communicates a pure red color, so deep that concentrated boiling solutions appear black. The solutions may be used for dyeing directly without fear, for the tissues will not retain a trace of the arsenic. If necessary, the arsenic may be easily removed from the coloring matter by one of the following processes:—

1. Powder the rough product, and treat it with strong hydrochloric acid; then dilute with water, and saturate the clear solution with a slight excess of soda. The coloring matter is precipitated, while the arsenic remains in solution in the alkali, and it is only necessary to wash the precipitate once or twice with cold water to obtain the coloring matter quite pure.

2. The rough product dissolved in water is treated with a quantity of quick-lime corresponding to the arsenical compounds it contains, *plus* a slight excess. The coloring matter is precipitated, as well as the arsenical compounds,—the latter in the form of insoluble calcareous salts. The liquor and the precipitate (unseparated) are now treated with carbonic, acetic, or tartaric acid, either of which will dissolve the coloring matter and leave the arsenic.

In this process, aniline gives about its own weight of coloring matter.

The process of MM. Depouilly and Lauth, "for the manufacture of various colored products derived from aniline," is very similar to that of Mr. Perkin. They take a solution of a salt of aniline and treat it with a solution of chloride of lime. The first drops of the chloride produce a violet coloration, and, on continuing the addition of the re-agent, a deep violet precipitate is formed, which constitutes the coloring matter. This is collected and washed with slightly acidulated water. When the washings are uncolored, the precipitate is collected

on a filter, and drained. It is then dissolved in a strong acid—sulphuric for example—and re-precipitated by the addition of a large quantity of water, or by an alkaline solution. The product is thus obtained sufficiently pure for sale. For dyeing and printing, alcoholic acid or aqueous solutions may be used, according to the nature of the article to be dyed and the purity of the color required.

The next patents referred to by the author are those of Messrs. Beale and Kirkham, Mr. Kay, Mr. Price, and Mr. G. C. Williams, which have been already described in the *Chemical News* (vol. i., pp. 9, 74, 81).

Electricity by Condensation of Vapor.

Prof. Palmieri records the following experiment: "I gently boiled water in an uninsulated capsule of platina, and condensed the vapors on a platina refrigerator, placed about two feet above the surface of the water; by a condensing electrometer, I detected positive electricity. Encouraged by this favorable result, I insulated the capsule upon the lower plate of a condensing electrometer, and concentrated the rays of the sun upon it by means of a lens of about a foot in diameter. I thus obtained a superficial ebullition scarcely visible, and signs of negative electricity in the capsule."—*Archives des Sciences Physiques et Naturelles*, August, 1860, p. 352.

Dissolving Platina in "Aqua Regia."

In operating on a large quantity of platina, a long time is required, during which the operator is exposed to the acid fumes; and frequently a loss of from 1 to 6 per cent. is experienced, owing to the formation of an insoluble chloride. Doctor Dullo finds that both these inconveniences may be avoided by boiling under a slightly increased pressure, which he obtained by passing through the cover of the mattrass a bent glass tube, the vertical branch of which contains a column of about 3 feet of water. The platina dissolved rapidly and left no residue.—*Jour. für Prak. Chem. Bull. Soc. d'Encour. pour l'Indus. Nationale.*

Colorless Caoutchouc Varnish.

Dr. Bolley recommends to cut the caoutchouc into small strips, and digest them in benzine, at the ordinary temperature; stirring or shaking the mixture frequently and long. The jelly which forms partly dissolves, and gives a liquid heavier than benzine, which may be made nearly colorless by filtration and repose. By pressing the residuum in a strong cloth, may be obtained a dark colored insoluble jelly, which makes a good adhesive covering. It incorporates well with all the fat and volatile oils, and dries rapidly: the surface is not shining. It is very flexible, and may be spread in thin coats.—*Dingler's Polytech. Jour. Bull. Soc. d'Encour. pour l'Indus. Nat.*

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, November 21, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President,
John F. Frazer, Treasurer,
Isaac B. Garrigues, Recording Secretary, } Present.

The minutes of the last meeting were read and approved.

Donations to the Library were presented by the Royal Society and the Society of Arts, London; the Oesterreichischen Ingenieur-Vereines, Vienna, Austria; A. Dallas Bache, LL. D., U. S. Coast Survey; Lieut. J. M. Gillis, U. S. Navy; Commissioner of Patents, Washington, D. C.; the Board of Water Commissioners of Jersey City, N. J., and Prof. John F. Frazer, Philadelphia.

Donations to the Cabinet of Minerals—from William T. Harris, Esq., Lancaster County, Penna.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of October.

The Board of Managers and Standing Committees reported their minutes.

Thirty-six resignations of membership in the Institute were read and accepted.

Candidates for membership in the Institute (13) were proposed, and the candidates proposed at the last meeting (9) were duly elected.

Mr. Howson, of the Committee on Meetings, exhibited the following articles:

1. A Cook Stove for army purposes, the invention of Mr. Isaac S. Williams, of this city. The stove is of sheet iron, of an oblong shape, and has an inner lining, which, when removed and inverted over the top of the stove, forms an oven. In this casing can be packed over eighty utensils to be used for culinary purposes, also a complete set of table articles for a dozen men. Mr. W. has taken steps to procure a patent.

2. An ordinary Springfield Musket, rifled and altered to a breechloader according to a plan invented by B. F. Joslyn, Esq., of Stonington, Conn. The movable breech tilts over laterally to allow for the insertion of the cartridge, and when depressed to its proper position forms, as it were, part of the barrel. This fire-arm, which has been patented in this country and throughout Europe, has been subjected to severe tests at the Washington Navy Yard, and has been highly recommended, owing to its simplicity, cheapness, and cleanliness.

3. A Military Hat, (invented and patented by E. L. Pascall, Esq., of this city,) which may be readily converted into a dress hat, fatigue cap, or havelock. It has met with the approval of military men, and has been adopted to a considerable extent in the army.

4. A package of Paper Bags, made by a machine invented and patented by Mr. H. G. Armstrong, of this city. Mr. Howson briefly

explained the main features of the machine, and stated that he considered it one of the most ingenious, simple, and effective inventions ever carried out in this city. No less than 800 complete bags can be made by this machine in one minute.

5. A fastening for Shoulder Straps, invented by B. G. Barney, Esq., of this city. It enables the wearer to readily detach the strap from and re-attach it to the shoulder of his coat. Mr. B. has applied for a patent.

6. A model of a combined Floating Battery and Battering Ram, the invention of J. R. Savage, Esq., of Camden, N. J. All the exposed parts of the battery are iron-plated, and so formed as to present an angle of 30 degrees to a shot striking in a horizontal direction. A movable rod or bar can be projected from below the hull, to penetrate the bed of the river or harbor, for the double purpose of anchoring the vessel and serving as a centre, around which it may be revolved by the aid of the rudder and propeller—the guns being thus directed to any desired point.

7. A very simple and ingenious Clasp for Shades of Coal Oil Lamps, the invention of Mr. C. Reichman, of this city.

8. A specimen of a Cravat, for which a design patent had been obtained by Mr. J. A. Eshleman. Mr. Howson stated that he exhibited this specimen with the view of showing the meeting what a number of articles of manufacture could be protected by the new act, which related to patents for designs, a subject as yet not generally understood.

A. C. Jones, Esq., presented an improved Coupling for attaching branch-pipes of fire engines to the nozzle, and also explained his improvements in Floating Batteries.

Henry Pickel, Esq., C. E., of this city, presented an improved Plane Table (for interior work) for Surveyors, consisting of a drawing-board supported on a tripod (theodolite pattern) with a sight ruler. This instrument supersedes the use of the prismatic compass, with field-book. No field-book is required with this instrument.

Also, a Comb Scale Calculator, for calculating the areas of cross-sections of cuttings, embankments, and interior work, with off-sets. With this instrument, Comb Scale Calculator, and a problem in Euclid, calculations of areas ordinarily requiring several hours, could be made in a few minutes, thus doing away with the use of any of the Mathematical Tables. Plans and surveys can be made complete, together with their areas, without the aid of a field-book, as stated.

Mr. A. L. Fleury, chemist and electrician, read the following papers:—

Can light, heat, and motion, successfully and economically be produced by electricity?

This is a very important question, and it is for our present fast-progressing century to answer it by practical demonstrations. Electricity acts the most important part in the mineral, vegetable, and animal economy:—it has been proved to be identical with the vivid and withering lightning, the streaming aurora borealis, the rapid whirlwind, the terrific waterspout, and may probably be the cause of

the falling meteor, and the devastating earthquake; it seems to be the connecting link between mind and matter—figuratively speaking, electricity is the soul of nature.

Already the successful experiments of Prof. Faraday, showing the advantages of the electric light for lighthouses, as also the brilliant trials lately made in Paris, give evidence that our neighbors over the water are on the *qui vive* in this most important subject: the production of light by electricity.

Not only this subject, but also that of heat has been taken into consideration. As proof, I present here an article published recently in the London *Times:*—

"A Trappist, named Delalot-Sevin, of the Abbeye de la Grace-Dieu, has made a discovery which will probably produce a revolution in the system of lighting and heating public and private buildings. He has invented a new pile much stronger and at the same time cheaper than the pile of Bunsen. By means of his photo-electric apparatus, he produces an electric light as cheap as gas; and with his thermo-electric pile, he supplies caloric on economical terms hitherto unknown. Several of these apparata have been constructed, and one is at full work in the Abbeye de la Grace-Dieu. Manufactories for the public are shortly to be established in Paris and at Lyons. The apparatus for producing gas will not be given to the public until after the exhibition at London next year; but that for heating buildings will be made public on the 16th of December next. The inventor has been authorized to make public experiments with his system of lighting on the Place Saint Jaques in Paris, and also on the Place Bellecourt at Lyons."

As to motive power, we learn that some of the most prominent electricians of France, England, Germany, and Russia, have for the last few years been most actively engaged in constructing machines, and it is said that the Emperor of France has given great attention and facilities to the scientists engaged in these important experiments.

Philadelphians: Your city, the home of the illustrious Franklin, has done much, perhaps more than any other city in the Union, to advance the sciences and arts. Shall we be outstripped by the efforts of our European neighbors?

I shall present to you this evening a communication of great importance on one of these subjects, the production of light and chemical decomposition, by a new magneto-electric apparatus, the invention of my worthy friend Dr. P. H. Vander Weyde, Professor of Chemistry and Physics at the Cooper Institute in New York. This gentleman has experimented for years past on magneto-electricity, and his communication is of interest and value. Perhaps at the next meeting of the Institute I shall be able to exhibit a large and powerful machine, producing a most brilliant electric light.

It is a remarkable—I may, perhaps, add providential—coincidence, that the aforementioned communication has been followed by another coming from a different source.

Mr. Herrman Haug, a Prussian engineer, lately arrived from Europe (a graduate of the Royal Polytechnic Institute at Berlin), sends a highly interesting communication on a *new Electric Motor.*

The advantages of a *cheap* electric motive power are too well known —the absence of fire alone, without taking into account the danger caused by the pressure of steam, or even of heated air—would give, even at a greater cost, to such a motor a high recommendation.

I reserve the reading of his communication for the next meeting, as it will require your full attention, involving some new and very peculiar modifications of natural laws. I can, however, show to you a drawing of a machine which has since been modified and perfected. It would be strange indeed should these two inventions secure to this country the honor, and why not the victory over our European rivals?

Mr. Fleury then read and explained by diagrams the following Description of New Magneto-Electric Machines, constructed on a principle differing from the usual method, by Dr. P. H. Vander Weyde, Instructor in Physics and Chemistry at the Cooper Institute, New York.

Last winter I read a paper before the Polytechnic Club of the American Institute, on the different methods of producing and using electricity to ignite inflammable substances. I exhibited the drawings and models of a few magneto-electric machines of my construction, adapted to ignite gas or gunpowder, by means of a magneto-electric current.

An extract from this paper and reports of the experiments performed are found in the Transactions of the American Institute for 1860, pp. 547-554, in a January number of the Scientific American, and in the American Engineer for January 10th, 1861.

I have since made numerous experiments to find the most advantageous arrangements to obtain the different purposes those machines may be intended for, have constructed small working models, and am now preparing two different very effective machines on a large scale.

Before speaking of my investigations since then, I will first in a few words describe the four new machines explained at that time, as this will serve to make the advantages offered by the two arrangements I have finally adopted better understood.

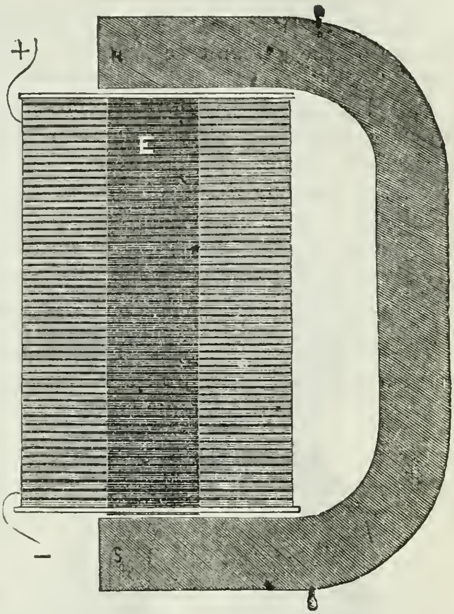
In each of my new arrangements, my purpose is (as the name "Magneto-Electric" indicates) to do away entirely with the cumberous and expensive galvanic batteries which are the main objections to the use of the Ruhmkorff-coil and other arrangements made after the same principle, and to substitute for the battery, the action produced by permanent steel magnets, moved by some mechanical power.

The question was only to arrange a given quantity of steel so as to obtain the strongest permanent magnetism, and to arrange a given quantity of insulated copper wire so as to obtain by that magnetism put in motion, the greatest amount of electricity.

First Arrangement.

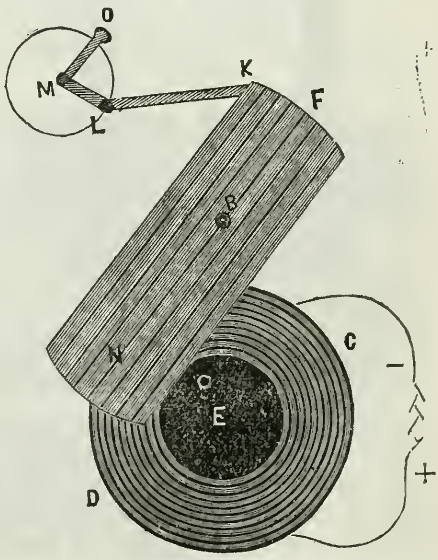
Of the first arrangement I contrived, the principle is represented in figs. 1 and 2, the first being the front and the second the side view of the apparatus.

Fig. 1.



It is an imitation of the Ruhmkorff-coil, except that in place of magnetizing the central iron core, E, by the current from a galvanic battery, (passing through a coil of thick wire, around which the long thin wire is wound,) in this arrangement the central iron core is magnetized by a bundle of horse-shoe magnets, oscillating around a pivot, B, and passing with their poles close along the extremities of the iron core. By this arrangement the central thick wire is entirely dispensed with; the thin wire of several thousand feet in length is wound directly on the insulating glass or india rubber surrounding the core, and also wound in sections, as is the case in the improved apparatus of Ruhmkorff; by which means, united with the perfect insulation of the windings from the core by glass, india rubber, &c., a long spark is produced.

Fig. 2.



I do not wish to have the value of this arrangement overestimated, and therefore will also mention its disadvantages.

1. The thick primary wire being omitted, the condenser, which increases the spark of Ruhmkorff's apparatus, and which is connected with this wire and the battery, cannot be here applied.

2. The magnetism cannot be so suddenly excited or neutralized in the central core, by the passing of the steel magnets along its extremities, as is the

case in the Ruhmkorff-coil, by making and breaking the contact of the battery; the suddenness of this operation constituting one of the sources of its efficiency.

3. The central iron core cannot be magnetized so strongly by the passage of the magnets along its extremities, as in the core by the passage of the galvanic current through a wire surrounding its whole length.

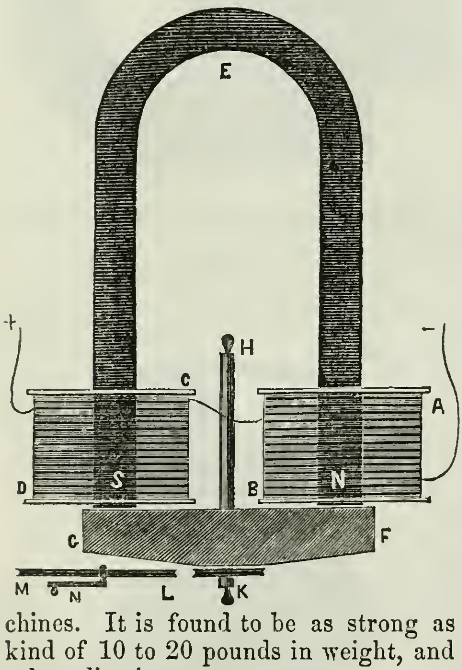
This last disadvantage is, however, more or less compensated by the closer proximity of our long wire to the central core, of which the magnetism is the principal source of the intensity current, giving sparks, in the long wire; as is sufficiently known.

I mention these particulars because, as I remarked above, they are useful, nay, necessary to understand the subject in question, and will also serve to appreciate the advantages of my other arrangements.

Second Arrangement.

The steel horse-shoe magnet, S E N, consisting of three or five superposed laminæ, is rounded off at the poles, around which the two coils, A B and C D, are wound; F G represents the soft iron keeper, revolving around the axis, H K, by means of the crank, N, and the intervening wheel-work, M L.

Fig. 3.



A small working model of this machine, intended to prove the correctness of the principle that the coil may be advantageously wound round the steel magnets, is now in the hands of my friend, Prof. Fleury, in Philadelphia. Its dimensions are so small that it may be carried in the pocket without the least inconvenience; for this reason I have it specially arranged for medical purposes, and attached to it the usual contact breaker and commutator of the good medical magneto-electric machines. It is found to be as strong as many large machines of this kind of 10 to 20 pounds in weight, and amply sufficient for all medical applications.

This arrangement (which I find to have been already made in France some four years ago) has two defects.

1. That the whole magnetic power of the steel is not taken advantage of, by winding alone the extremities.

2. That by revolving the soft iron in front of the magnet we have

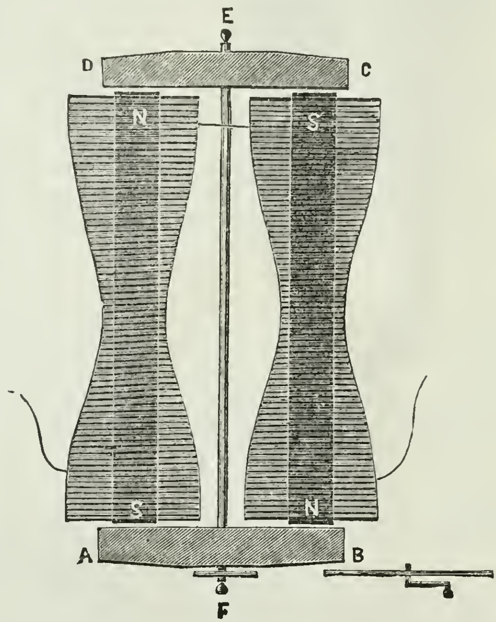
no perfect contact, and do not make all the magnetism latent, thus exciting the current only with the difference of the full and a greatly diminished power.

I have succeeded in obviating these difficulties by two separate arrangements, which are the subject of my patent.

Third Arrangement.

I have taken two steel bars, each composed of a bundle of five or seven laminæ, strongly united and rounded off; each is surrounded by a hollow cylinder of glass, india rubber, or any other good insulating substance, of the same length as the bars, and open at both ends; around these the coil is wound for the whole of their extent, observing two things: first, to wind it in sections, as the Ruhmkorff-coil, to insure more length of the spark; secondly, to so distribute it over the length of the magnetic bars, that most of the coil will be where the greatest magnetic intensity resides, that is, towards the extremities.

Fig. 4.



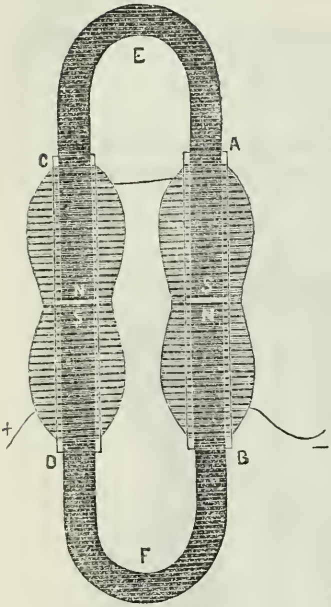
The two bars and coils are then horizontally attached to a board or placed in a box, equally distant from and parallel to an axis, which is a little longer than the steel bars.

In fig. 4, N S represent the steel bars and coils, E F the axis; at each extremity of this axis is attached a keeper, A B and C D, at right angles, and at such a distance that by turning the axis the keepers pass with their ends very closely along the extremities of the steel magnets, which of course lay with the opposite poles toward the same keepers. It is clear that in this arrangement we have the advantage of the whole magnetic surface of the steel magnets, being made available by the coil, and at the same time working with an apparatus more than double the power of that represented in fig. 3, and exactly of the same dimensions.

The remaining disadvantage of imperfect contact of the keepers and magnet, is entirely overcome in the following:

FOURTH ARRANGEMENT.

Fig. 5.



I take two strong horse-shoe magnets, having polished cylindrical extremities, E and F, and place them horizontally on a board or in a box, touching each other with their opposite poles, N S, which are situated in two coils, A B and C D. These coils, wound of well insulated copper wire, are immovable, and fixed to said board. One of the magnets must slide in and out of the coil, and may be suddenly separated from the opposite fixed magnet which attracts it, by means of a strong lever. The moment this is done, the magnetism of the two magnets (before made latent by their contact) is suddenly set free, and induces an electric current in the coils; by joining the magnets again, a current will be developed in the opposite direction, which, if desired, may be led in the same direction by means of an appropriate commutator attached to the lever.

The machines described under Figs. 4 and 5 have both peculiar advantages, which adapt them to perform electric labor of a different nature, which I will now explain.

In the machine represented by Fig. 4, the contact cannot be absolute, and therefore is the magnetism of the steel magnets not so entirely neutralized as in Fig. 5; therefore the electric power of Fig. 4 is due to the difference in the full magnetic power of the steel, and its power diminished by about 98 per cent. In Fig. 5, the magnetism is almost entirely destroyed by the absolute contact, so that scarcely a trace is left; however, to compensate for this slight defect in machine Fig. 4, these machines are apt to run with great velocity while Fig. 5 is not.

Fig. 4 is therefore appropriate to the following purposes:—

I. *For Electro-plating*, if a series of medium-sized machines are constructed, connected by thin coils, and moved together.

II. *For Chemical Decomposition.* If these series are so constructed that the connexion of their coils may be arranged differently, either for intensity or for quantity; as the coils and magnets are all stationary, it is exceedingly easy to change these connexions, even while the machine is running, till the intended result, chemical decomposition, is obtained. However, as I find the law of Ohm (that the resistance in the conducting wire or coil must be equal to the resistance in the liquid of the battery) applicable to these machines, in which the resistance of the coil must be equal to the resistance in the chemical solution to be decomposed, we may, by calculating the resistance which

this liquid offers to the electric current, connect the coils in such a way as to make the resistance in them equal to that in the liquid, and thus arrange the connexions *â priori.*

III. *For Medical Purposes*, if the machines are constructed on a small scale, and provided with a commutator, as in the machine (No. 3 above) now in the hands of Prof. Fleury.

IV. *For Electric Light*, if the precautions in the construction are adopted which I have found by many successful experiments to be necessary to secure a long spark, and which thus far have never been obtained in machines of this kind. Of these precautions and peculiar arrangements, I will speak hereafter. They are of absolute necessity for the apparatus represented in Fig. 5, which is the great desideratum so long sought for and wanted for military purposes.

V. *For Igniting Gas, Gunpowder, and other inflammable substances.* For this purpose, the machine Fig. 5, is to be constructed with special regard to obtaining a single but very powerful spark.

To obtain such a spark, the precautions are:—

1. To have the magnets carefully rounded off at the poles, well fitting, and exactly filling the opening in the coils.

2. To have the ends well ground on a plane, to secure a perfect contact.

3. To insulate the coil carefully in winding it over the glass or india rubber, to prevent the spark from losing its intensity and length by discharging partially through the magnets, as is the case in all other machines; also, to avoid the mistake of having metallic or other conductive rings connected with those coils, which absorb a part of the electric effect of the magnets at the expense of the coils.

The necessary peculiarities of the arrangement are:—

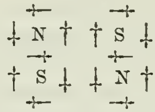
1. To construct each magnet of a bundle of smaller magnets, each of such size and shape as have been found by Lamont the most effective (see Poggendorf's *Annalen*, July, 1861).

2. To insulate the extremities of all these small magnets from one another, so as to prevent the circulation of any electric current in the bundle of magnets (to the production of which there is a tendency), and thus to force all the magnetism producing the electric current to be exerted in the coil.

3. To wind the coil in a peculiar way (described in Poggendorf's *Annalen*, a few years ago), to insure longer sparks. A single apparatus of this kind suffices for igniting gas or gunpowder by means of some easily explosive compound, as I have proved by experiment, even with the old apparatus (see Transac. Am. Inst., 1860, p. 549). Where, however, more intensity is required to make it work at greater distances, a battery of such coils as Fig. 5 is to be arranged by placing the magnets vertically: the upper ones fixed, and the lower ones movable, so that, by the downward motion of a powerful lever, they may be at once separated from the upper, each pair surrounded by its coil.

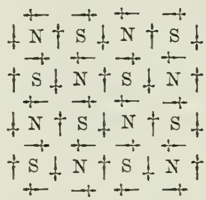
The way these poles have to be arranged, is for the lower magnets (that is, those having their poles turned upward, if we look from above

down on them) here represented; N signifies the north pole, and S the south pole, of each horse-shoe; the arrows indicate the direction of the current in the coils, and the way these coils must be connected.



It will be seen how, by this arrangement, every pole assists the currents in the coils of the neighboring opposite poles; those four poles are neutralized by the contact of the opposite poles of the upper inverted magnets, but this inverted position brings the current in the same direction.

For 16 poles, the arrangement would be thus; the arrows again indicating the direction of the current:—



Such a combination will require the full power of one or two men to separate the sixteen poles by means of the lever, but by my careful and peculiar arrangement, will give an electric spark equivalent to the power applied, and will act at any distance which practically may be wanted, only requiring the common precaution for insulating the conducting wires.

The patents applied for, cover all the essential parts of the machines represented in Figs. 4 and 5, as well in their single construction as in their combination to a powerful battery, and the use of this battery for the purposes mentioned, as also for such effects as can be produced by any ordinary electric machine or galvanic battery.

Cooper Institute, New York, Nov. 10th, 1861.

Mr. Howson presented a Calisthenic or Gymnastic Apparatus, invented by Mr. R. A. Maxwell, of Eleventh and Chestnut Streets, which attracted much attention. This instrument occupies a space of about two cubic feet, and can be regulated to give a resistance of from 6 to 600 lbs. All exercises for which cumbrous devices and gymnasia are provided, can be practised by the aid of this instrument.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.

October.—The month of October was warmer than usual. The mean temperature was greater than that of any October for the last eleven years, and was one-third of a degree greater than in October, 1858, which had heretofore been the highest.

The warmest day of the month was the 6th, of which the mean temperature was 78·3°. The highest degree of heat indicated by the register thermometer was 88°, on the same day.

The coldest day was the 28th, with a mean temperature of 43½°. The register thermometer indicated the lowest degree (34°) on the same day.

The range of temperature for the month was 54°.

The greatest change of temperature in the course of a day was 25°, on the 15th; the least was 8½°, on the 10th; and the average oscillation for the month (16·94°) was more than one degree greater than the general average, but less than one degree more than that of October, 1860.

The greatest mean daily range of temperature was 13°, and occurred between the 7th and 8th days of the month; the least was 1·3°, and occurred between the 9th and 10th. The average daily range for the month was 5·28°, which was about a quarter of a degree less than usual. It was less than in any October since 1857, when the average daily range was 4·3°.

The greatest pressure of the atmosphere was 30·452 inches, and was observed at 7 A. M. on the morning of the 25th. This is the highest point indicated by the barometer, in the month of October, during the eleven years of observation. The highest heretofore (30·410 ins.) occurred at 9 A. M. on the 27th of the month, in the year 1852. The minimum pressure was 29·469 inches, and occurred at 2 P. M. of the 30th. The monthly range of pressure was 0·983 of an inch. The average pressure for the month was fifteen-thousandths of an inch less than for October, 1860, but five-thousandths of an inch greater than the average for eleven years.

The greatest mean daily range of pressure was 0·423 of an inch, between the 23d and 24th; the least was 0·03 of an inch, between the 18th and 19th; and the average for the whole month was 0·166 of an inch, which is greater than any average daily range of pressure for this month since 1853, when it reached 0·170, and it is nearly two-hundredths of an inch greater than the average for the eleven years of observation.

The average relative humidity was greatest on the 19th and least on the 28th of the month. The average for the whole month, as computed from that of the regular hours of observation, was 72½ per cent. of complete saturation, which is almost the same as that of October, 1860, but 3 per cent. greater than the average for the last eleven years.

The force of vapor was also greater than usual. At every hour of observation it was greater than before observed in this month for the last eleven years. The average for the whole month was 0·399, while the general average for the whole time of observation was 0·331 of an inch. The force of vapor was greatest (0·731 in.) on the 7th, and least (0·122 in.) on the 28th of the month.

The dew-point, following the force of vapor, was also greater than for any other October for the last eleven years. The highest was 69·9°

on the 7th; and the lowest, 22·7° on the 28th. The mean dew-point for the month at 7 A. M. was 48·65°, at 2 P. M. 51·43°, and at 9 P. M. 51·07°, making the average for the month 50·38°. The average height of the dew-point at 2 P. M. for this month for the last eleven years was 46·67°.

Rain fell on ten days of the month, to the aggregate depth of 3·597 inches, which was one inch less than that which fell in October, 1860, but three-quarters of an inch more than the average for the whole time of observation.

There were but two days of the month, the 14th and 28th, entirely clear, or free from clouds at the hours of observation, and the sky was completely covered with clouds at those hours on nine days of the month. The average amount of cloudiness was nearly one-tenth of the sky more than usual. The average amount of sky covered for October for the last eleven years was five-tenths, while for the last month it was almost six-tenths.

On the morning of the 28th of the month, ice was formed in exposed places in the western part of the city, the sixteenth of an inch in thickness. It has not yet been observed in the built-up parts of the city. The first ice was observed last year on the 21st of November.

A Comparison of some of the Meteorological Phenomena of OCTOBER, 1861, *with those of* OCTOBER, 1860, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Oct. 1861.	Oct. 1860.	Oct. 11 years.
Thermometer.—Highest, . .	88°	79°	90°
" Lowest, . .	34	36	28
" Daily oscillation,	16·94	16·10	15·77
" Mean daily range,	5·28	5·80	5·55
" Means at 7 A. M.,	54·32	51·58	51·28
" " 2 P. M.,	66·61	63·29	63·36
" " 9 P. M.,	58·69	55·61	55·50
" " for the month,	59·87	56·83	56·71
Barometer.—Highest, . .	30·452 in.	30·275 in.	30·452 in.
" Lowest, . . .	29·469	29·312	29·012
" Mean daily range, .	·166	·119	·145
" Means at 7 A. M., .	29·945	29·963	29·937
" " 2 P. M., .	29·893	29·906	29 895
" " 9 P. M., .	29·926	29·938	29·916
" " for the month,	29·921	29·936	29·916
Force of Vapor.—Means at 7 A. M.,	·373 in.	·321 in.	·318 in.
" " " 2 P. M.,	·415	·363	·350
" " " 9 P. M.,	·410	·354	·324
Relative Humidity.—Means at 7 A. M.,	81 per ct.	80 per ct.	79 per ct.
" " " 2 P. M.,	60	61	57
" " " 9 P. M.,	76	77	74
Rain, amount in inches, . .	3·597 in.	4·685 in.	2·855 in
No. of days on which rain fell,	10	13	8·8
Prevailing winds—Times in 1000-ths,	N75°10′W.·211	S75°58′W ·069	N73°40′ W ·251

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